A STUDY OF PERI URBAN AIR QUALITY AND LAND USE CHANGES USING GIS APPLICATION IN YOGYAKARTA CITY, INDONESIA

by

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Abstract

The rapid development has shifted the urbanization to the peri-urban area. This has enhanced quality of life in the socio-economic aspects. On the contrary, the UN found that the urban lifestyles have been the major cause of the environmental degradation due to the consumption patterns of the natural resources. This has contested the principle of the sustainable development which suggests the socio-economic enhancement should go along with environmental protection. Furthermore, the city now is not only a place for physical development, but also for developing the people capacity thus it must provide a viable environment for working as well as for contented living.

The uncontrolled suburbs-sprawl in the northern fringe of Yogyakarta Urban Area has caused enormous loss of agricultural lands and indicated an adverse effect to the ambient air quality due to vehicular emission. According to the Provincial Environmental Impact Control Agency, one of the monitoring stations in northern peri-urban area recorded over-limit ambient lead level in 2004. The ambient lead pollution issue has been raised because the leaded gasoline is still widely distributed in Yogyakarta City and 95% of the motorized vehicles are using this fuel.

This occurrence should alert the urban planners that integrated planning is a must in order to have a livable city. This study will try to seek the correlation of land use changes and transportation factors to the ambient lead level in peri urban area using multiple linear-regressions method with the aid of remote sensing technology and GIS application for land use changes identification. Thus, it will facilitate the planners and decision makers to deal with lead pollution issue in the northern fringe of Yogyakarta Urban Area.

Table of Contents

Chapter	Title	Page
	Title Page	i
	Acknowledgements	ii
	Abstract	iii
	Table of Contents	iv
	List of Tables	vi
	List of Figures	vii
1	Introduction	1
	1.1 Background of the Study	1
	1.2 Identification of Research Problem	3
	1.3 Objectives	4
	1.4 Scope and Limitation	4
	1.5 Concluding Remarks	5
2	Literature Review	6
	2.1 The Concept of Livable City	6
	2.2 Definition and Classification of Land Use	9
	2.3 Transportation and Ambient Air Pollution	18
	2.4 Transportation and Its Characteristics	19
	2.5 Ambient Lead Pollution	27
	2.6 Urban Green Area and Ambient Lead Pollution	30
	2.7 Land Use Change, Transport and Ambient Lead Pollution	32
3	Research Design and Methods	37
	3.1 Research Methods	37
	3.2 Introduction to Research Location	38
	3.3 Research Procedure	41
	3.4 Type of Data	43
	3.5 Data Gathering Methods	45
	3.6 Data Analysis	49
4	Land Use Changes	50
	4.1 Demographic Profile	50
	4.2 Urban Morphology and the Spatial Characteristics	51
	4.3 Land Use Changes and the Leap Frog Development	56
	4.4 Driving Forces of Land Use Changes	68
	4.5 Concluding Remarks	70
5	Transportation and the Ambient Lead Level	71
	5.1 Transportation System	71
	5.2 Traffic Volume and Composition	72
	5.3 Fuel Characteristics	74
	5.4 Public Transportation	74
	5.5 Traffic Monitoring	76
	5.6 Ambient Lead Monitoring	82

	5.7 Concluding Remarks	83
6	Correlation of Land Use Changes and Transportation to the Ambient Lead Level	84
	6.1 Multiple Linear-Regressions with OLS Method Analysis	84
7	Conclusion and Recommendation	86
	7.1 Conclusion	86
	7.2 Recommendation	87
8	References	89
9	Appendices	93

List of Tables

Table	Title	Page
2.1	The Critical Component of Livable City	7
2.2	The Differentiation of Rural, Rural-Urban and Urban Char.	9
2.3	Land Use Classification	9
2.4	The Ideal Ratio of Land Use Zone in Urbanized Area	11
2.5	Land Development and the Environmental Issues	13
2.6	Emissions by Type of Fuel Used	18
2.7	Characteristics and Issues of Traffic and Transport	19
2.8	Travel Speed of Passenger Vehicle within Urbanized Area	20
2.9	Characteristics of Traffic Flow based on V/C Ratio	21
2.10	The Indicator for Better Air Quality in Yogyakarta Province	34
2.11	Land Use and Transportation Parameters	35
3.1	The Research Methods and Its Characteristics	37
3.2	Research Objectives and Projected Required Data	42
3.3	Primary Data and The Gathering Method	43
3.4	Secondary Data and Its Source	44
4.1	Demographic Prof. of Depok, Ngaglik and Pakem Dist., '97 –'06	50
4.2	The Number of Students of All Degree in UGM and UII, '97 – '05	50
4.3	The Growth of LU Changes of Depok, Ngaglik and Pakem Dist., '88 – '02	56
5.1	Traffic Monitoring in Kaliurang Street Corridor, 2005 - 2006	76
5.2	Ambient Monitoring of 1hr-Pb Concentration from 2001 to 2006	82
6.1	The Regression Result of Land Use Changes and Transportation Factors to Ambient Lead Level (OLS method)	84

List of Figures

Figure	Title	Page
2.1	The Concept of Livable City in Chiang Mai, Thailand	8
2.2	Types of Urban Sprawl Process	13
2.3	The Remote Sensing Applications	15
2.4	Format of Vector Data	16
2.5	Format of Raster Data	17
2.6	Example of GIS Applications for Land Use Inventory	17
2.7	Type of Private Cars	21
2.8	Type of Medium-Heavy Vehicles	22
2.9	Four-strokes Motorbikes	22
2.10	Rickshaw and Horse-drawn Carriage	22
2.11	Road Segment in Urban Area	23
2.12	Road Segment in Outer-urban Area	23
2.13	Toll Way in Urban Area	23
2.14	Four-legs Intersection with Traffic Signal	24
2.15	Four-legs Intersection without Traffic Signal	24
2.16	Geometry of Road Segment with Shoulder and Median	25
2.17	Geometry of Road Segment with Shoulder but without Median	25
2.18	The Potential Conflicts in Four-legs Intersection	26
2.19	Distribution of Lead Emission on the Roadside by Smith (1976)	28
2.20	The Adv. Effects of Pb Pollutant to Human, Animals and Plants	29
2.21	*Cassia seamea* and Its Leaves Structure	31
2.22	*Pithecellobium dulce* and Its Leaves Composition	31
2.23	*Filicium decipiens* and Its Leaves Structure	31
2.24	*Swietenia mahogany*, Its Bark and Leaves Structure	32
2.25	*Polyalthia longifolia* and Its Leaves Structure	32
3.1	Map of Yogyakarta Special Region (DIY) Province	38
3.2	Current Developments in Yogyakarta City and Its Vicinity	39
3.3	High Volume Air Sampler (HVAS)	45
3.4	Quickbird Image 2005 of Kaliurang Street from Km 2 to Km 8	46
3.5	The Comparison of Satellite Image Resolution between BPPD Sleman Image and DigitalGlobe Image	47
4.1	The Land Use Map of Yogyakarta Urban Area Interpreted from SPOT XS Images 1996	51
4.2	The Land Use Map of Sleman Regency in 1999/2000 and in 2005	52
4.3	Land Use Zoning of Depok Municipality	53
4.4	Land Use Zoning of Ngaglik Municipality	54
4.5	Land Use Zoning of Pakem Municipality	55
4.6	The LU Allocation of Depok, Ngaglik and Pakem Dist., ‘00 – ‘06	57
4.7	Statistical Figure of Building Density in 15 Spots along Kaliurang Street Corridor	58
4.8	Existing LU Map of Kaliurang Street Corridor from km 3 - km 17 Depicted from Quickbird Img. 2005 and DigitalGlobe Img. 2007	59
4.9	Point A - Mirota Kampus Supermarket Intersection	60
4.10	Small-Medium Scale Businesses in Point C (Gading Mas Minimarket)	60

4.11	The Changes in Point A and Point C	61
4.12	The Forest Laboratory of UGM	61
4.13	Business Place in Colombo Market and in Gentan Market	62
4.14	Telecommunication Shops in Pakem Market	62
4.15	The New Building Features in front of Social Agency Book Store	63
4.16	The Main Gate of Up-Mid Class Housing in Kaliurang Sreet km 9	63
4.17	The Traffic Light Signal in the T-junction of Merapi View	64
4.18	Newly-built Shop "BarkaS" next to WS Minimarket	64
4.19	Tourism Facilities in Kaliurang Street km 16	65
4.20	The Botanic Farm Shops	65
4.21	The Surroundings of Toraja Seafood Restaurant	66
4.22	The Commercial Area in front of UII Campus	66
4.23	The Extraordinary Student Facility in front of UII Campus	66
4.24	Informal Sectors in Point A	67
4.25	Snacks Booths across Gading Mas Supermarket in Point C	67
4.26	Various Kinds of Informal Sectors Business	68
4.27	The Driving Force of LU Changes in Kaliurang Street Corridor	69
5.1	Transportation System Map of Sleman Regency, 2005	71
5.2	The Growth of Motorized Vehicle in Ygy. Urban Area, '01 -'03	72
5.3	Pctg. of Mot. Veh. in Depok, Ngaglik and Pakem Dist., '97 - '05	73
5.4	Fuel Trade in Yogyakarta Urban Area, 2004 - 2005	74
5.5	Type of Public Transport Means in Kaliurang Street Corridor	75
5.6	Facility of TransJogja Bus in Mass Transit Prog. in Ygy. City	75
5.7	Terminal Booth of TransJogja Bus	76
5.8	The Geometry of Intersection in Point A	78
5.9	The Roadside Activities in Point A	78
5.10	The Geometry of Kaliurang Street in Urban Setting	79
5.11	The Garbage Cart and Bicycle in front of Gading Mas Minimarket (point C)	79
5.12	Parking on the Roadside in Colombo Market (point F)	79
5.13	The Reckless Street-crosser with Motorbike in Kentungan Intersection (point D)	80
5.14	The Geometry of Kaliurang Street in Rural-Urban Setting	81
5.15	The Geometry of T-junction of Merapi View (point J)	81
7.1	Illustration of Livable City in Peri-urban Area in Yogyakarta City	91

Chapter 1
Introduction

1.1 Background of the Study

In the beginning of the 20th Century, there was only 13% of world's population lived in urban areas. Today, there are almost half of the world's total population and over three-quarters of high-income countries' population living in urban areas. Cities have become the center of attention as major consumers and distributors of goods and services. Along with the development, a city has never stopped growing and expanding. Cohen (2004) predict over the next 25 years, most of the urban growth in the world will not take place in mega-cities at all but will occur in secondary cities and towns as the population still rapidly grows.

Many secondary cities have taken on new functions and operated as the center of legal and economic activities. These new functions require a wide range of specialized services and facilities as well as many other physical developments which need more land, resources, and energy to accommodate the urban growth (Sassen 1998 in Azocar et al., 2005). All those socioeconomics activities and interactions would create certain patterns in land use, transport infrastructure, as well as consumption of natural resources that establish the urban spatial structure (AURDR 1995 in Marquez and Smith, 1999).

On the other hand, the UN found that the urban lifestyles have been the major cause of the earth degradation due to the consumption patterns of resources (Roelofs, 1996). Cities are major consumers of natural resources and therefore are major waste generators. This brings more pressure to our planet. This may hamper the development, thus city cannot provide a place for an excellent quality of life.

The UN Agenda 21 calls for countries to achieve sustainability in development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". This infers that it is vital to improving the quality of life in a city, including ecological, cultural, political, institutional, social and economic components thus city can be a livable place without leaving a burden on the future generations.

In order to accomplish that goal, urban plan is in use as a legal instrument to control and manage the urban environment as well as to guide its growth in desired directions. However, since the city has never stopped growing, planning process becomes an everlasting and demanding practice, particularly when it concerns a wide range of interrelated topics. Nevertheless, the invention of various state-of-the-art-technologies has facilitated a great deal for urban planners to carry out such task. One of the most useful technologies for urban planning is the latest remote sensing technology and GIS applications. Geographic Information System (GIS) is one tool for data analysis of the earth's environment and its phenomenon using the remote sensing data. The GIS application is an integrated operation of hardware, software, geographical data input and skilled human resource to organize, manage, analyze and display all forms of geographically referenced information (Puntodewo et al., 2003; ESRI, 2007).

Yogyakarta City is one of rising secondary cities in Indonesia. It is famous for the cultural and historical tourism as well as the education. It is very rich of the classical Javanese fine arts and culture because it was initially founded in 1756 as a great kingdom of Central Java. In 1950s, the city used to be the capital of Indonesia. In the capital city, the citizen must be well-educated. This initiated the government to highly encourage education enhancement in Yogyakarta City. Although the capital has been moved to Jakarta City, Yogyakarta is still famous for the education. Until today, both tourism and education sectors are the main economic basis in Yogyakarta City.

In regards of the impact to the environment, education sector has been worse than tourism. Education sector has triggered the excessive population growth, increased more activities, as well as enlarged the disturbance to the environment in Yogyakarta City since every year, 6000 college students come and stay to pursue higher education. Most of the universities are scattered in the suburbs which spread the benefit as well as the adverse effect of the urban primacy (Rachmawati et al., 2004).

Yunus (2003) has recognized that there is a rapid loss of agricultural land in the suburbs of Yogyakarta City from 1992 to 2002. With the advance in remote sensing technology, urban land use change and urban features can be captured and identified on the satellite imagery (Sutanto, 1999). Using LANDSAT satellite image and GIS tools, Brontowiyono (2004) studied the land use change in Yogyakarta City and its vicinity from 1994 to 2000. The result shows that agricultural lands have been rapidly changed to housing and its infrastructure with the change growth 1.41% per annum. Along with that, many facilities and amenities have also been thriving, especially along the main road connecting urban and the suburbs where the university is located. This has generated more traffic activities from suburbs to the city.

Mass transport is expected to accommodate the excessive demand (Roelofs, 1996) but the leap frog development has made public transportation system hard to run since it is expensive and inefficient to provide the facility and infrastructure. As a result, numbers of private vehicle are rapidly increasing every year. Motorbike is exceedingly dominating since it is more convenient and relatively less costly than car. The Logistics and Transportation Research Centre of Gadjah Mada University recorded that growth of motorbike is 2500 unit per month. Today, there are 250 thousand motorbikes, 33 thousand passenger cars, and 3 thousand buses and trucks. Government should be alarmed with these numbers. Many road sections are no longer adequately accommodate the traffic flow. The excessive traffics from the fringe areas to the city cause serious traffic congestions in several urban arterials. In the last 10 years, the congested traffic flows are getting worse and creating air pollution harming the people and the environment not only in the city but also in the suburbs.

The Regional Environmental Impact Control Agency (BAPEDALDA) of Yogyakarta Province has done regular monitoring of ambient concentrations of hazardous air pollutants at 15 most congested locations in Yogyakarta Province from 2002-2006. The monitoring data recorded 5 potential air pollutants consecutively as follows: Total Suspended Particulate (TSP), NO_2, SO_2, CO and lead (Pb) which shows the ambient air is gradually deteriorated. In most monitoring locations, ambient concentration of those pollutants were recorded fairly below the standard except for some locations where 24hr-concentration of Pb were increasing sturdily until exceeding the emission standard in 2005 (BAPEDALDA, 2004 in ADB, 2006).

Pb pollutant is not quite well-known in the general public. It is less famous than carbon emission which is the trigger of the hottest issue “Global Warming”. However, the effect of Pb pollutant is not less harmful than of carbon, especially to human health. Pb is one of respirable particles with diameter smaller than or equal to ten micrometer (PM_{10} or less). Over-exposure to Pb may cause disruptions to the hemoglobin (Hb) creation, damage the fetus growth in the pregnancy which may lead to death of the infant, and to the intelligence growth especially in the age of early development (Soedomo, 2001).

According to ADB (2006), source of Pb particles in Yogyakarta City is from the incomplete combustion of vehicles’ engines which use leaded gasoline. The local authority has been promoting the use of unleaded gasoline since 1996 as it would promptly reduce the emission of Pb particles in the ambient air. Due to its costly price, only a few people shifted to unleaded gasoline. Therefore, the risk of Pb pollutant to human health is still persistently high. This will lead Yogyakarta City away from sound sustainable city.

In order to improve the quality of live in Yogyakarta City, studies and researches are continuously undertaken as part of the urban planning process to help urban planners and policy makers perceive feasible option to deal with air pollution and its impact, particularly Pb pollutant, so that the city can be a better place to live for the present as well as the future generations.

1.2 Identification of Research Problem

In 2004, one of the monitoring stations in peri-urban area has recorded high level concentrations of Pb pollutant. The monitoring station is located in Kaliurang Street, the vital urban arterial connecting the city with the northern suburbs. According to data from BAPEDALDA (2004), the level reached 2.2$\mu g/m^3$, while the emission standard is 2.0$\mu g/m^3$. ADB (2006) reported that source of Pb particle is from the incomplete combustion of vehicles’ engines which use leaded gasoline. Nowadays, gasoline with lead is still widely distributed in Yogyakarta City, although local authority has been promoting the use of unleaded gasoline since 1996.

In the same time, Yunus (2003) has studied that there has been enormous land use change from agricultural use to non-agricultural use in Yogyakarta City and the fastest change happens in the northern part. Brontowiyono (2004) has recognized that the agriculture land has been changed into housing and infrastructure sprawled in the suburbs. Despite of the quality and availability of natural resources, the sprawl has been triggered by two most famous universities located in Kaliurang Street, Gadjah Mada University (UGM) which was founded in 1949 in kilometer 4.0 and the foundation of Indonesian Islamic University (UII) in 1990 in kilometer 14.0 (Rachmawati et al., 2004). Both universities have the highest enrollment fee in Yogyakarta Province with quality assured education system.

These two prestigious universities have attracted middle-upper class society from other provinces to study in Yogyakarta City. According to Academic Affair Division of both universities, almost 75% of the students are coming from other provinces with superior background. Thus, it has created high-class student’s lifestyle environment along Kaliurang street. Most of the lands alongside the street, especially in the proximity to university, are utilized as fancy restaurants, café and lounge, boutiques, video rentals, game centre and computer and electronic shops to facilitate the contented lifestyle of students, not to forget about the basic students’ facilities such as photocopy shops, stationery, bookstore, internet café, laundry shops, and mechanic shops. This leads to high traffic generation. Since public transport is not adequately provided, number of private vehicles multiplies vastly. Ammari (2005) observed that motorbike is the most favorable vehicle since it is affordable and convenient for personal transport within the city area. The statistical record from 2000 to 2005 shows that the growth rate of motorbikes is 11.9% per annum, higher than cars, 6.9% per annum (Ammari, 2005). From Sleman municipality data in 2003, the total number of registered motorized vehicles is 270,648 and 85% of the traffic composition is dominated by motorbikes. However, the statistical figure may not be precisely reflecting the number of motor vehicle since there is an issue of unregistered vehicle owned by students from other provinces.

The rapid growth of vehicles is not going together with the expansion of road section because of practical and financial issues (Dishub DIY, 2007). As a result, traffic congestion cannot be avoided. Congested traffic flow will exacerbate the emission from motorized vehicles (Reksohadiprodjo and Brodjonegoro, 1989).

The congestion in Kaliurang Street is exaggerated also by inappropriate development of facilities and amenities for students. Based on field observation, most of them do not have sufficient parking area so that many are using the road side area. According to MKJI (1997), roadside parking is one of disturbance factors for optimum road capacity. Moreover, most of the commercial places in the roadside also do not have any vegetation to catch and absorb the pollutant particles. Roadside vegetation is one kind of urban green areas that had just been stated in Laws 28/2007 about Urban Land Use Planning. According to Fandeli et al. (2004), certain kind of vegetation can absorb great amount of lead particles so that it significantly reduces the concentration of pollutant which will reduce the harm to the environment and human health as well. Although there have been guide and regulation, to date, local government has not taken any explicit action yet.

Thus, this study will try to describe the correlation among land-use changes, transportation and air quality to provide scientific and actual information about lead pollution in Yogyakarta City and its vicinity. The central question in this study is to what extent, and in what ways, land use changes and transportation are related to ambient air quality, particularly Pb level.

1.3 Objectives

The objectives of this study are:

1. To describe the characteristics of existing land use pattern due to land use changes and the changes driving forces in the in study area;
2. To describe the state of transportation and ambient Pb level due to the enormous growth of motorized vehicles in study area;
3. To describe the correlation among land use changes and transportation to ambient Pb level.

1.4 Scope and Limitation

The scope of the study is a peri-urban area in the northern fringe of Yogyakarta City which is experiencing some environmental issues due to the sub-urban sprawl process from 1997 to 2007. The study area is administered by different kinds of legal institution, thus researcher experienced some constraints and limitations in practicing the research procedure, particularly in data gathering.

Many of government agencies have not been alerted that environmental issue has no geographical boundary. There is still lacking of an integrated system to monitor the state of the environment of the study area. The environmental-related information has been scattered, thus it is quite a strenuous effort to track it down. This also makes many environmental policy, plan and programs are still precarious in the practical implementation.

Moreover, even though the latest remote sensing technology and GIS application are available, there are still some shortcomings in the implementation due to financial constraints and the capacity of human resources. Although it facilitates the urban planning a great deal, the satellite image is not easily reached in a regular price, particularly the latest as well as fine quality one which is discerned from its pixel resolution. Furthermore, lacking of the skilled personnel is also hindered this remarkable advantage of the technology for the comprehensive planning's benefits.

1.5 Concluding Remarks

There have been many studies on the relationship of land use change and the environment in Yogyakarta City in vicinity, but only few are related to air quality. Nowadays, the economic development triggered by education- and tourism-related industries has fostered the rapid urban growth extensively and intensively. Extensively, the urban growth has expanded to the suburbs and intensively, the intensity of land use has been changing from low-intensity use into higher intensity. The land use change has lead to urban sprawl phenomenon which triggered more intensive traffic generation. Inefficient public transport system has increased the number of motor vehicles and created traffic congestion because of insufficient road capacity. Congested traffic will exaggerate the air pollution from vehicular emission. This study will try to look at the correlation of land use, transport and ambient air quality with the help of GIS and remote sensing technology. Thus, it will help planners and policy makers to perceive feasible options to deal with air pollution which support the sustainable practice in Yogyakarta City and its vicinity.

Chapter 2

Literature Review

This chapter is determined to provide theoretical background and previous studies and researches in order to critically look at the current issue on urban environmental aspect especially about land use change and ambient air quality due to urban sprawl phenomenon from 1997 to 2007 in Yogyakarta City and its vicinity. The discussion will include a brief introduction to the idea of livable city as a manifesto of sustainable development. Then, it will be continued by urban land development and its environmental issue followed by brief description on land use definition and classification as well as on the remote sensing and GIS technology to study land use/land cover change. After that, the discussion will be continued to the transportation characteristics and its association to ambient lead pollution as the most critical pollutant issue in Yogyakarta City.

2.1 The Concept of Livable City

City is an engine of economic growth and cultural prosperity, but more important, it is also a home to people. Thus, it should be safe and secure as a place for living. The concept of livable city has been initiated by urban planners in cities in developed countries as one effort to promote sustainable and equitable development embraced from the UN Agenda 21.

The term “livable city” has just emerged in early 2000 in developed countries and recently adopted in developing countries, thus there are not many theoretical references about the particular subject. However, the idea of a livable city is practically the substance of sustainable development which encourages economic growth and social enhancement without ignoring the environmental protection through better political role (Timmer and Seymoar, 2005).

A livable city cannot be defined precisely, but it can be established by identifying elements that contribute to making urbanized area a pleasant place to live and work. Smithson defined a livable city is a friendly places for people which is reflected in the following discourse,

> “...the relationship between street and building, and buildings amongst themselves, and trees, and seasons of the year, and ornamentation, and events and other people (Smithson in Palej, 2000 in Timmer and Seymoar, 2005)”.

According to Lennard (Lennard, 1997 in Timmer and Seymoar, 2005), the basic principles to the livable city are as follows:

1. All the inhabitants can see and hear each other instead of being segregated and isolated.
2. Public participation in planning is essential, thus they may determine the future of their city.
3. The city shall offer activities and events that bring opportunities for its inhabitants to be together as ordinary human beings.
4. The city shall be free from fear and any conceptions of crime and injustice.
5. The city shall be a place for social learning where the inhabitants respect and value each other as well as impart wisdom and knowledge.

6. The city must assemble many functions in economic, social and cultural dimensions.
7. The physical and social beautifications are two elements of the same consideration in the realm of urban planning.

Meanwhile, Cools (Cools, 1997 in Timmer and Seymoar, 2005) has viewed city as a living organism. The metaphor of the city as a living organism has better symbolized the critical components of a livable city as represented in Table 2.1.

Table 2.1 The Critical Component of Livable City

LIVABLE CITY METAPHOR	**COMPONENTS**	**DESCRIPTION**
The brain and nervous system of the Livable City	Governance and Public Participation;	Engage the active involvement of a diversity of citizens in visioning, planning, implementing and monitoring regional plans and place-based solutions to challenges.
	Monitoring;	The monitoring capability of a livable city is equivalent to the nervous system in a living organism.
	Measuring; and Learning	Develop the capability to: 1. To measure progress towards its goals; 2. To encourage experimentation and test new ideas; 3. To learn from experience; 4. To adapt strategies in order to take into account dynamic circumstances and shifting priorities; and 5. To quickly respond to opportunities and challenges.
The heart of the Livable City	Common Values; and a Sense of Identity and Place	Provide an active public realm for: 1. For reflecting the essence of itself; 2. For creating and reinforcing a common identity; 3. For dialogue about common values; 4. For remembering history; 5. For celebration and festivals; and 6. For socialization of children and young people.
The organs of the Livable City	Inclusive Communities;	An inclusive communities with mixed-use and affordable housing close to shopping, employment, cultural centres and pedestrian-friendly transportation networks;
	Vital Downtown Core;	A vital downtown core with public spaces and economic activity;
	Industrial Clusters; and	Industrial clusters with shared infrastructure;

	Green Space	Green space including agricultural lands and parks.
The circulatory system of the Livable City	Natural Resource Flows; Green Corridors; Energy Grids; Communication; and Transportation	A livable city is connected through: 1. Through the flow of resources that sustain its activities including water, materials, sewage, and waste as well as through access to energy resources; 2. Through green corridors for biodiversity habitat and recreation; 3. Through access to the communication systems including information and communication technologies 4. Through a transportation network that prioritizes walking, public tansportation and efficient movement of goods, and enables pedestrian-friendly communities.

Source: Developed from Cools, 1997 in Timmer and Seymoar, 2005

Vancouver, Canada is one of cities which have best practices on livable city. Planners in Vancouver have been assessing on the livability concept related to sustainable development in Greater Vancouver Regional District (GVRD) since 1972. The planning has emphasized on physical land use, density and transportation issues to explore the buoyant of urban system due to complexity and dynamic processes of the city. In order to put the livability concept into reality, an integrated planning approach is necessary to address the urban system through socio-economic, political and ecological dimensions and their interconnections (Timmer and Seymoar, 2005).

In 2002, the concept has been spread out to Thailand as a program on city management with the aid from US AEP (KIAsia, 2003). One of the cities that currently adopt the livable city concept is Chiang Mai (see Figure 2.1).

Figure 2.1 The Concept of Livable City in Chiang Mai, Thailand
Source: www.kiasia.org

Figure 2.1 illustrates the concept of livable city implemented in Chiang Mai, Thailand as a city management program. This conception would guide urban planners to manage the city as well as achieve sustainability by establishing balanced range of all sustainable components together. However, to date, studies, training and workshop on livable city concept for developing countries in are still pursued to share experiences and observe the best practices.

This study has been done to observe the livability issue due to the sprawled development to the suburbs of Yogyakarta City, Indonesia from two physical environment aspects which are land use and transportation. Both elements will be further elaborated consecutively in the following sections.

2.2 Definition and Classification of Land Use

The term land use is defined by Meyer and Turner II (1994) as human employment to the land. The feature of the land utilization is mostly characterized by the prevailing activities on the area (see Table 2.2), which will impinge on the land use classification system (Yunus, 2003).

Table 2.2 The Differentiation of Rural, Rural-Urban and Urban Characteristics

No	Aspect	Rural	Rural-Urban	Urban
1	**Livelihood**	*Agriculture*	*Mixed*	*Non-agriculture (heterogen)*
2	**Working Space**	*Open space*	*Mixed*	*Covered area*
3	**Work Distance**	*Close to house location*	*Mixed*	*Far from house location*
4	**Population Density**	*Very low*	*Low*	*High*
5	**Building Density**	*Very low*	*Low*	*High*
6	**Pattern of Built-up Area**	*Sporadic*	*Sporadic*	*Compact*
7	**Community Characteristic**	*"Gotong-royong" (helping one another)*	*Transition*	*Formal*
8	**Transport Mode**	*By walking or un-motorized vehicles*	*Mixed means of transportation*	*Complex*
9	**People Mobility**	*Very low*	*Medium-High*	*Very high*

Source: Developed from Nelson, 1955 and Amiruddin et al., 1970 in Yunus, 2005

Although many have tried to define the land use classification, Sir Dudley Stamp has given the first detailed classification in 1930 for studies on United Kingdom. To date, it is still being used as the root of many other land use classification. Mujtaba (1994) modified it into a three level general land use classification which will be presented in Table 2.3.

Table 2.3 Land Use Classification

Level I	*Level II*	*Level III*
Built up Land	Residential	Upper-middle class housing Lower-middle class housing
	Commercial	Traditional market CBD
	Industrial	Small factory

		Large factory
	Transportation	National road
		Regional road
		Local road
	Educational	School
		University
	Institutional	Bank
		Post Office
		Hospitals
	Recreational	Park/Garden/Zoo
		Playground/Stadium
		Race Course
		Museum/Exhibition/Monument
Agricultural	Agricultural	Crops
		Plantation
Wastelands	Land with or without scrub	Graveyards, etc
	Barren rocky area	Barren rocky area
Water Bodies	River/Stream	River/Stream
	Tank/Lake	Ponds/Reservoir
Others	Grass	Grasslands
	Plot lay-outs	Construction site

Source: Developed from Mujtaba (1994), pp 47-52

From the table above, it can be acknowledged that **Level I Land Use** is the simplest yet lucid classification of spatial distribution. According to Mujtaba (1994), the aforementioned terms in Level I Land Use can be defined as follows:

(1) *Built-up Land* is defined as an area of human habitation developed due to non-agricultural use and that which has a cover of buildings, transport, communication, utilities in association with water and vegetation.
(2) *Agricultural Land* is defined as the land used for agricultural activities such as farms, cropland, fallow and plantations.
(3) *Wastelands* are described as 'under utilized lands' with or without vegetation cover. Most of the wastelands are loosing the soil fertility, so they are not suitable for cropland. However, they may be improved and used for forest or for grasslands.
(4) *Waterbodies* are the areas impounded and occupied with water, either stagnant or flowing through.
(5) *Others* are including all those which can be treated as miscellaneous because of their nature of occurrence, physical appearance and some other specific characteristics. This category is flexible and can accommodate uses which have not yet available in classification system.

Land use classification is hierarchical where the higher level is the breaking down of the lower level. Thus, the definition of the terms in ***Level II*** and ***Level III*** is a detail elaboration of the uses in ***Level I***. Some of the uses will be described as follows:

(1) Built-up Land
   (a) *Residential Area* is defined as any of those lands which people use for their dwelling by using bricks, cement, concrete and steels.
   (b) *Commercial Area* is defined as business centers where selling of finished products is carried out for day to day usage in urban areas. These areas are usually intermixed with residential area. In some place, commercial areas can form a definite cluster with a core such as Central Business District (CBD).

(c) *Industrial Area* is the land where any of the manufacturing activity exists where people work for their livelihood.
(d) *Transportation* is the space used for mobility of people. It includes airports, railway stations, roads, railways and harbours.
(e) *Public Facilities* is the space for educational centers, offices, military accommodations and anything similar to those activities.
(f) *Recreational Area* is the place where people visit to seek entertainment like parks, playgrounds, open or close theatre.

(2) Agricultural Land

This uses will not be further detailed in regards to the land use in urban area.

(3) Wastelands

(a) *Land with or without Scrubs* are lands with thin soil cover or which is in degraded conditions with no presence of plants or else leading to the growth of small and sturdy plants and scrubs.
(b) *Barren Rocky Area* is the area with rock exposure of varying nature and often lack of any vegetation.

(4) Water Bodies

(a) *River/Stream* is a natural course of flowing water on the land along carved channels.
(b) *Tanks/Lakes/Reservoirs* are stored and impounded water bodies. Lakes are natural large impounded water bodies whereas tanks are smaller lake or ponds of waters. Reservoir is an artificial lake created by constructing a dam across the natural feature.

(5) Others

(a) *Grasslands* are the areas covered with naturally growing grasses, although some are maintained by man. Such lands are found along riverbanks, hill slopes and lake shores.
(b) *Plot Layouts* are vacant lands mostly developed by real estate agent for construction of buildings.

Rooted on the classification above, land use can be functioned to describe the urban environment. Fandeli et al. (2004) explains that even though land use in urbanized area is dominated by built up territory, it should be including the proper amount of green space as well. The appropriate ratio of land use share in urbanized area is shown in Table 2.4 below.

Table 2.4 The Ideal Ratio of Land Use Zone in Urbanized Area

No	**Land Use Zone**	**Area**
1	Housing and Settlement	40 %
2	Commercials and Industries	15 %
3	Offices and Institutional Building	10 %
4	Transport and Infrastructure	20 %
5	Urban Green Area	15 %
	Total	**100** %

Source: Developed from Fandeli et al. (2004), pp 10

From Table 2.4, it is inferred that the minimum share of covered/built up area and the green area is 65% - 15% and the rest of the land is assigned to the road and infrastructures. However, most cities in developing countries have enormously allocated the land into built up area such as housing, commercials and industrial areas. Fandeli et al. (2004) emphasized that along with rapid urbanization process, the green area is one significant entity in land use to maintain the sustainable development. Planners and decision makers need to take this substance into consideration.

2.2.1 Land Development in Urbanized Area and the Environmental Issues

It is predicted globally that most development in millennium era will take place in secondary cities and towns because the rapid population growth and the increase of human activities in urbanization process need more land and other natural resources (Cohen, 2004; Yunus, 2005). The great invention of automobiles has endorsed the settlement clusters to further remote area, which then altered the forest and farmland area and increases travel demand to reach workplace and commercial areas in city core (Shore, 2006). Land use change in urban development will involve either an alteration from one use to a different use or an intensification of the existing one (Meyer and Turner II, 1994). This phenomenon has triggered uncontrolled land use change which expanded the physical urban growth beyond the city administrative boundary and ruined the concept of the city as a compact entity (Yunus, 2005).

This type of growth is acknowledged as urban sprawl phenomenon. Several definitions of the term urban sprawl are defined as follows,

> ”Urban sprawl refers to the areal expansion of urban concentrations beyond what they have been. It involves the conversion of land peripheral to urban centers that has previously been used for non urban uses to one or more urban uses (Northam, 1975 in Yunus, 2000).”

> ”Urban sprawl refers to the continuous expansion around large cities, where by there is always a zone of land that is in the process of being converted from rural to urban use (Harvey and Clark, 1971 in Yunus, 2000).”

> ”Urban sprawl can be defined as the growth of metropolitan area through the process of development of miscellaneous types of land use in the urban fringe areas (Domouchel, 1976 in Yunus, 2000).”

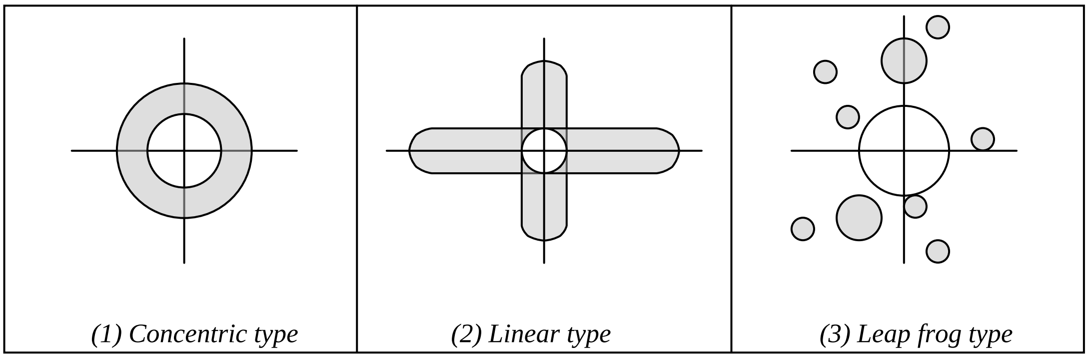
According to Yunus (2000) there are three types of urban sprawl process which are as follows:

(1) Concentric development
The term concentric development was introduced by Wallace, 1980 in Yunus, 2000. This type is also known as low density continuous development (Harvey and Clark, 1971 in Yunus 2000) because it has the slowest urban sprawl process. The sprawl is fairly distributed around the city peripheral. There is not much influence to the process from transport system.

(2) Ribbon development
In ribbon development, the sprawling process takes place along the urban transport routes. The main route usually has the biggest pressure from this type of development.

The land value in the sprawl area is increasing and therefore many farmers have not much choice except to give up their land for urban development. Ribbon development is also known as linear development or axial development.

(3) *Leap frog development*
Leap frog development is the sporadic growth of building within the agricultural lands which makes it visually unpleasant and economically inefficient to provide the service and infrastructure. It creates such a spatial structure that makes people uneasy to move from one place to another with a short walk, makes public transportation system difficult to operate efficiently and therefore, creates high dependency to automobiles (Roelofs, 1996). In addition, leap frog development will also bring adverse effect to land resources and decrease productivity in agriculture.



Legend : ☐ City core ☐ New development of urban land use
Source: Modified based on Yunus, 2000

Figure 2.2 Types of Urban Sprawl Process

In the realm of planning for sustainability, leap frog development is the most incompatible type of sprawl. Basuki (1993) has noted that this type of development will lead to inefficiency of natural resource consumption and create more environmental deterioration which is not in accordance with the livability concept. The uncontrolled land development issues and the potential environmental problem will be briefly elaborated on Table 2.5.

Table 2.5 Land Development and the Environmental Issues

No	Land Development Issues	Potential Environmental Problem	Causes
1	*Improper land use plan* ▪ Conflicting land development ▪ Unfit land use allocation	1. Air, water, soil and noise pollution	1. Uncontrolled and unguided land development
2	*Inadequate land resource* ▪ Poor soil condition ▪ Rapid growth demand	1. High cost of new environment facilities 2. Traffic congestion	1. Lack of infrastructure 2. Poor land development 3. Non-integrated planning

3	*Adverse land use* ▪ Loss of historical heritage site ▪ Loss of natural assets ▪ Lack of open and green space	1. Deterioration of visual beauty and cultural properties 2. Unpleasant neighborhood	1. Lack of awareness 2. Poor resources management 3. *Laissez-faire* growth
4	*Ecologically unsustainable land use* ▪ Land subsidence ▪ Construction projects ▪ Rapid urbanization	1. Loss of agricultural land 2. Loss of recreational area	1. Lack of Environmental Impact Assessment 2. Poor resources pricing

Source: DCP, 2003 in Wongbumru, 2005

In regards to air pollution, it can be inferred from Table 2.5 that as one of the potential environmental problem, air pollution is caused by sprawled development in the city, particularly the leap frog type. Roelofs (1996) explained that leap frog development has caused inefficiency in the provision of public transport system and therefore created high dependency to cars. In the long run, this will increase the numbers of vehicle and create heavy traffic which then creates more emissions that exaggerate the pollution to ambient air.

Although there are many viewpoints can be used to observe and analyze the growth of the city, this study will focus on the spatial growth which is better be looked from land use point of view (Mujtaba, 1994). Land use illustrates the pattern of physical growth of particular area by presenting spatial distribution of human activities as well as utilization of natural and non-natural resources (Basuki, 1993). Thus, land use analysis would be best describing the mutual relation of human's behavior and its surroundings (Ritohardoyo, 2002). Moreover, Westerlund (1979) believes that land use has been the essence of urban planning since 1910s when cities began to be analyzed in terms of zone that is found homogeneous in function and use.

In urban morphology, spatial growth can be quantified using three indicators which are (1) type of land use; (2) pattern of built up area; and (3) pattern of circulation (Smailes, 1981 in Yunus 2005). In order to identify the rapid physical growth, remote sensing technology has helped a great deal to acquire the current urban features (Yunus, 2005). By using satellite, the rapid changes in land use, urban expansion, and building density can be depicted in remote sensing imagery. However, the satellite image alone cannot be used to identify the urban spatial growth. GIS applications shall be utilized to process all the imagery data into various thematic data necessary for the land use analysis. The definition and classification of land use as well as the advantage of remote sensing technology and GIS application for land use inventory will be further discussed in the following two sections.

2.2.2 A Remote Sensing Technology and GIS Application on Land Use Inventory

In globalization era, urbanization moves very fast. Thus, managing the overall urban environment is becoming a strenuous task in urban planning. In order to facilitate planners, remote sensing technology has come as a valuable tool for encompassing the entire scene. Using the help of electro-magnetic radiation, the latest technology of remote sensing can obtain accurate information about an object, area or phenomenon without being in contact with the subject matter (see Figure 2.3) (Mujtaba, 1994). The satellite will record an imagery data and produce an aerial photograph of the earth surface in color. This satellite image will then become the most valuable geospatial data which can be utilized in many development aspects. In order to take the great advantage of the satellite image, GIS Application needs to be utilized.

GIS stands for Geographical Information System, has been initially known in early 1980s along with the development of hardware and software in computer technology and become very popular in 1990s until today. The GIS application is an integrated operation of hardware, software, geographical data input and skilled human resource to organize, manage, analyze and display all forms of geographically referenced information (Puntodewo et al., 2003; ESRI, 2007) including the remote sensing data such as maps, aerial photography and satellite images to integrate the spatial and non-spatial data.

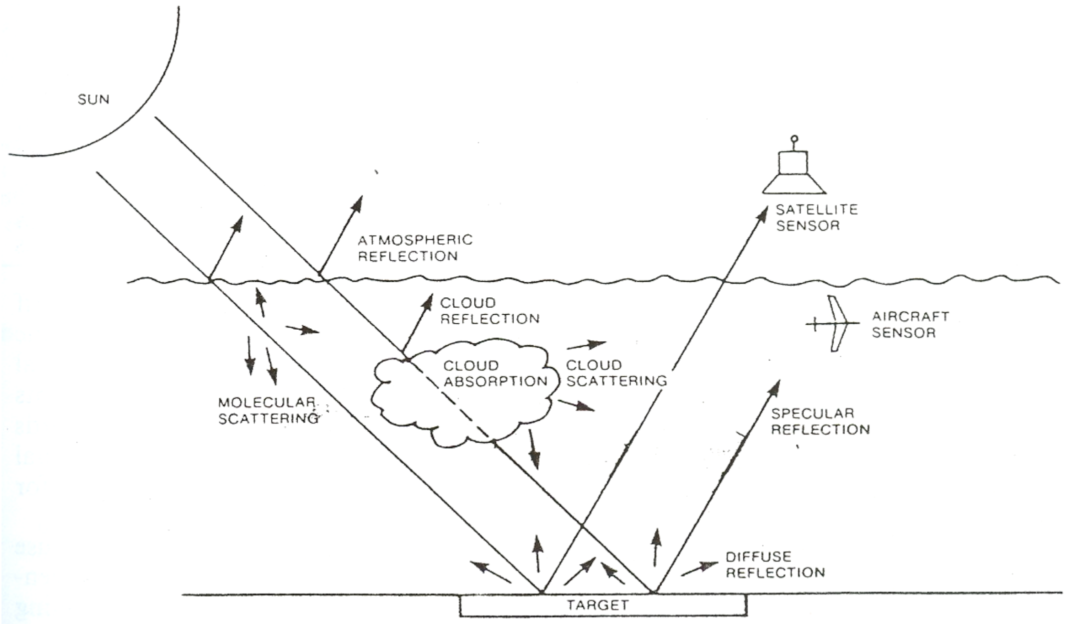


Figure 2.3 The Remote Sensing Applications
Source: J. Ronald Eyton in Ford, 1979; pp 3

According to Sugiharto (1998), GIS tools can describe position of objects related to the coordinate system as well as attach the attributes pertain to the research purpose and show the spatial interrelationship with each other. Moreover, GIS application can depict the existing condition, pattern and trends as well as can be utilized as modeling system (Puntodewo et al., 2003). Thus, GIS application has more value than the other information system. However, as it is mentioned in the definition, the operation of GIS is very much depending on the hardware, software, data input and the capacity of human resource which will be consecutively discussed as follows:

1. Hardware
   PC/Laptop with high-end specification (minimum Pentium IV, 512 RAM)
2. Software
   The software is used to organize, manage, analyze and display all forms of geographical information including the remote sensing data such as maps, aerial photography and satellite images to integrate the spatial and non-spatial data. The types of software are ArcView, ArcGIS and MapInfo.

3. Data input
   There are two kinds of data input for GIS application which
   (1) Spatial data
       Spatial data provide information of location, includes analog maps (e.g.: topography map and type of soil map) as well as remote sensing data (e.g.: satellite image and aerial photography).
   (2) Non-spatial data
       Non-spatial data is an attribute or descriptive information of one locality such as type of vegetation, number of population and per capita income. This information is acquired from separate data collection through ground truth observation in one locality.
4. Capacity of human resource
   Capacity to operate GIS application includes the sharp skill to operate the GIS software as well as to interpret and analyze the result.

Sutanto (1999) explains that GIS applications start with the identification of objects recorded on the satellite image using the software. The object of interest may be directly or indirectly distinguished. For the visible objects such as building or parking lot, the inference is based on the deduction of spectral, spatial, and also temporal characteristics of the objects. For the object which is not discernable, however, indirect associative should be adopted for the inference.

The identification of spatial data can be represented in two formats which are as follows:

1. Vector Data

In vector format, the object feature on the earth surface will be represented as a mosaic from dot/point, arc/line, nodes and polygon. The advantage of this format is the accuracy to represent spatial border and straight line features. The spatial data will be best represented in vector format when the data analysis deals with boundary, position and location information (e.g.: to describe the spatial interrelationship among the features). However, it can hardly recognize the gradual change in color.

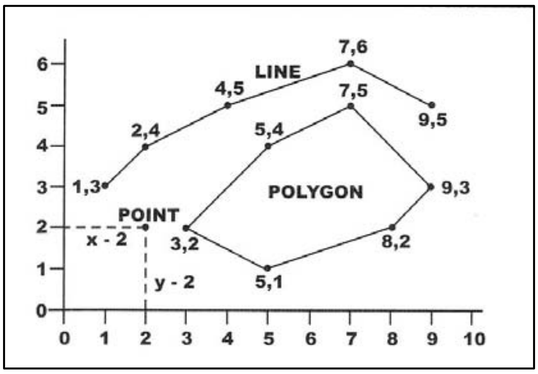


Figure 2.4 Format of Vector Data
Source: Puntodewo et al., 2003; pp 9

2. Raster Data

Raster data is produced by remote sensing system. In this format, the data is represented in grid cell structure called *pixel* (picture element). The resolution of the data depends on the pixel size. The pixel resolution depicts the actual size on the earth surface which is represented in each pixel on the satellite image. If each pixel represents a smaller size of the actual feature, the resolution is getting higher.

The raster data is best utilized to represent spatial borders which change gradually such as type of soil, soil humidity, soil temperature and vegetation. The disadvantage of raster format is it has a large file size as the grid resolution gets higher.

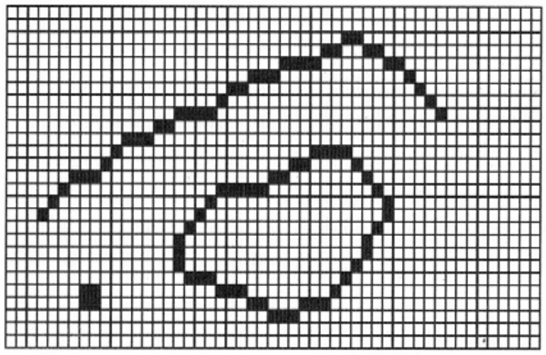


Figure 2.5 Format of Raster Data
Source: Puntodewo et al., 2003; pp 9

Each format has its own advantage and disadvantage. The selection to use the format depends on the purpose of study, the availability of data input, the desired data accuracy and the simplicity of analysis (Puntodewo et al., 2003). Based on these criteria, the spatial data for land use inventory is best represented in Vector Data Format (see Figure 2.6).

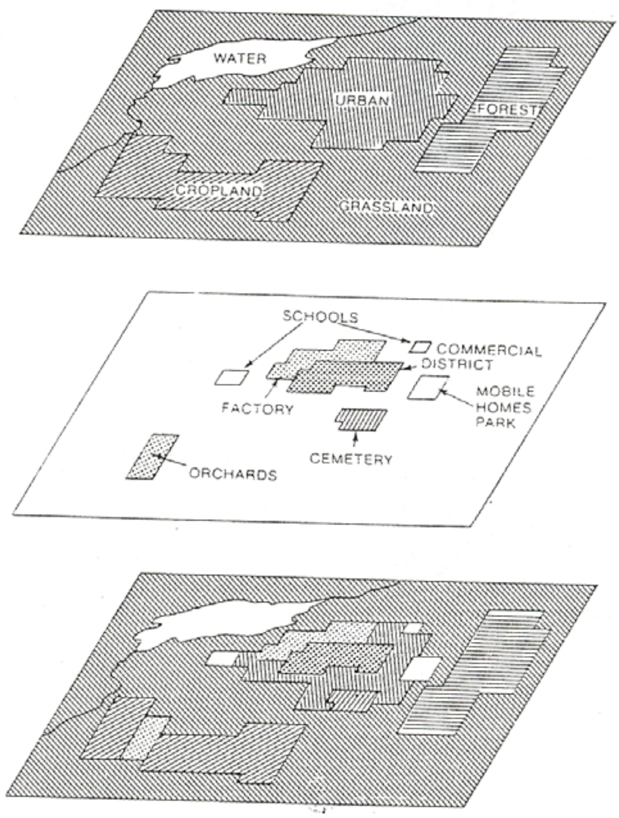


Figure 2.6 Example of GIS Applications for Land Use Inventory
Source: Bendix Aerospace System Division in Ford, 1979; pp 38

After the spatial data is represented, interpretation needs to be conducted for further analysis. Interpreting the remote sensing data in Indonesia is not an easy task because the technology has been developed in industrial countries where all urban features is wellarranged so that the interpretation of remote sensing data is much easier to do (Sutanto, 1999). However, there is no quantitative measure for interpretability (Sabins, 1997 in Sutanto, 1999). Thus, Sutanto defined the interpretability of an object is greatly affected by the spatial resolution of the remote sensing system, the contrast ratio, the environmental complexity, the interpreter's ability, and the image scale.

2.2.3 The Scope of Land Use Change Analysis

Using GIS Applications, the land use inventory can be manifested in the land use pattern in particular area. The pattern of land use is a result of complex interaction of processes in various range of scale in space and time. The range of scales for each process can be determined over which it has significant influence on the variables that drive the actions of the agents to change the land use pattern. In micro scale analysis, the focus is human's behavior with the individual or small groups as the unit of analysis. It is lack of spatial perspective because it ignores the context of the studied behaviour. In macro scale analysis, the measurement of relevant variables is only quantified by statistic correlation and therefore it is lack of ability to establish causality (Dolman, 2003).

Because of the complexity, the study of land use change cannot be limited only to a single scale for measurement and prediction (Gardner, 1998; Geoghegan et al., 1998; Allen and Star, 1982; Levin, 1992 in Dolman, 2003) because it will not give sufficient explanation of the phenomenon. Dolman (2003) explained multi-scale approach is critical to link the socioeconomic and biophysical processes for more comprehensive analysis of the driving force of the land use change.

2.3 Transportation and Ambient Air Pollution

What is ambient air and how can it get polluted? Darmono (2001) explained that naturally, the air that we breathe contains not many kinds of gas, dominated by nitrogen (78%) and oxygen (21%). The rest are just vapor and few other gases in very low proportion such as argon (less than 1%) and carbondioxide (0.035%). Among those few gases, some are identified as air pollutants which are very harmful to human health and the environment if they present in high concentration. Unfortunately, these gases keep increasing as human activities increase, especially in urbanized area where development mostly takes place. This has caused severe issue of air pollution which is the most complex and multifaceted problem, in term of source, type, effects and mitigation measure (Gupta, 2006).

Transport study in Indonesia shows that 81% of air pollution in urban areas is caused by vehicles tailpipe emission, especially in traffic congestion (Ammari, 2005). The pollutants include hydrocarbon (HC), Hydrogen (H), Carbon monoxide (CO), Carbon dioxide (CO_2), and Nitrogen oxide (NO) (Reksohadiprodjo and Brodjonegoro, 1989), which depends on the type of fuel used to run the engine (Kojima et al., 2000) (see Table 2.6).

Table 2.6 Emissions by Type of Fuel Used

	Type of engine based on the type of fuel	
	Diesel engines	**Gasoline engines**
Emissions	Particulate matter (PM_{10} or less)	Particulate matter (PM_{10} or less)
	Nitrogen oxides (NOx)	Nitrogen oxide (NOx)
	Sulfur oxides (SOx) (if the level of sulfur in diesel is high)	Carbon monoxide (CO)

		Organic lead (if leaded gasoline is used)
		Volatile organic compound (VOC)

Source: Based on Kojima et al., 2000

ADB (2006) reported that the gasoline distributed in Yogyakarta City and its vicinity is still using the lead additives. According to the Table 2.6 above, organic lead is one of critical air pollutant when leaded gasoline is used. Moreover, 95% of motor vehicles in the city are gasoline-fueled engines and the rest 5% are diesel-fueled (DISHUB DIY, 2007). Thus, ambient lead pollutant becomes the special concern in this study.

In order to forecast the vehicle emission rate in urban area, the primary info required from the travel activity is the speed, time and density of traffic (Stopher and Fu, 1998) and the emission should be estimated for the peak hours not on the average day (Dishub DIY, 2007). Moreover, Ammari explained that the pollution has been exaggerated by traffic congestion. Based on the study of Transport Bureau of Yogyakarta City, the congested traffic has been caused by enormous growth of traffic volume which is dominated by motorized vehicle without any enhancement in road capacity (DISHUB DIY, 2005; 2006). Thus, the following discussion shall begin with transportation factors, and then brief introduction to ambient lead pollution and its adverse effects.

2.4 Transportation and Its Characteristics

Transportation system is originally composed from two components which are traffic and transport. Traffic is defined as mobility of vehicles, people and also animals on the road whereas transport is defined as the action to move one or more object from one place (origin) to another (destination) (Warpani, 2002). Both components have the same basic elements which are: (1) land use; (2) road network; and (3) node (e.g.: bus terminal, train station and harbor). On the other hand, they have their own characteristics as well as distinctive issues with different kind of approaches to respond. However, to get better understanding to traffic problem, we need to investigate also the transport system, and vice versa. The detail of both characteristics will be presented in Table 2.7.

Table 2.7 Characteristics and Issues of Traffic and Transport

	TRAFFIC	**TRANSPORT**
Main Element	1. Street users (vehicle and non-vehicle) 2. Road network	1. Loads (people and goods) 2. Transport mode (motorized and non-motorized vehicle)
Issue	1. Volume of street users (V) 2. Road capacity (C)	1. Quantity of loads (L) 2. Capacity of transport mode (M)
Dimension	V/C	L/M
Potential Problems	1. Congestion 2. Chaos 3. Accidents	1. Uncurbed loads 2. Overloaded vehicle 3. Uncomfortable and unsafe
Potential Solutions	1. Enlargement of existing road 2. Developing new road network 3. Traffic tactics 4. Decreasing the traffic volume	1. Increasing the quantity of vehicle 2. Offering several modal choices 3. Operating mass transport system

Source: Based on Warpani, 2002

In traffic sector, Warpani (2002) explained that problems will be encountered when the volume of traffic is nearly close to the capacity the road section, leading to traffic congestion. The congestion will exaggerate the air pollution from vehicular emission because the idle and/or decelerated engines emit more incomplete combusted emission including lead rather than the normal or accelerated ones (Reksohadiprodjo and Brodjonegoro, 1989; Kojima et al., 2000).

Ammari (2005) found that because of the congestion, the average travel speed within the city has been decreasing every year. In 1995, the range of travel speed for all type motorized vehicle in the city was 6.1 – 6.7 m/s in peak hours and 8.9 – 10.6 m/s in off-peak hours. The study in Jakarta as metropolitan city showed that the average travel speed was decreasing from 10.6 m/s in 1995 to 9.6 m/s in 2002. In order to have well-observation of traffic condition, the Ministry of Transportation has set the tolerable travel speed within the city during peak hours, off-peak hours and the average speed level, as shown in Table 2.8.

Table 2.8 Travel Speed of Passenger Vehicle within Urbanized Area

	Metropolitan City	Large City	Medium City	Small City
Peak hours (m/s)	6.22	6.50	6.72	6.39
Off-peak hours (m/s)	10.40	9.81	9.39	8.89
Average speed (m/s)	7.69	7.42	7.67	7.28

Source: Draft of National Policy on Urban Transportation, 2005 in Ammari, 2005

Moreover, according to Dishub DIY (2005; 2006), the best indicator to observe the traffic condition is the level of congestion, and the measured indicator for congestion level is V/C ratio. The V/C ratio is the ratio between the traffic volume and the roadway's or intersection's capacity. The value of V/C ratio may reveal the level of congestion as well as the traffic condition on the spot, through the analysis from the manual established in Table 2.9 (MKJI 1997; Dishub DIY, 2005; 2006).

The value of V/C ratio is derived from the allotment of traffic volume (V) and road capacity (C). In Indonesia, the assessment of the traffic volume (V) and the road capacity (C) used to follow the manual from Europe and USA. However, the western methods were impractical because of certain differences in traffic composition, driving behavior and development of the roadside area. Therefore, in 1997, the Ministry of Transportation has modified the manual to be appropriate with transport and traffic characteristics in Indonesia, namely *Manual Kapasitas Jalan Indonesia* (MKJI).

Table 2.9 Characteristics of Traffic Flow based on V/C Ratio

Level of Service	Characteristics	V/C Ratio
A	Low traffic volume with liberated flow which allow high velocity on the road. Drivers have free selection of vehicle speed.	0.00 – 0.19
B	Unwavering traffic current condition. Drivers may select vehicle speed in tolerable level.	0.20 – 0.44
C	Unwavering traffic current condition. However, there is limited choice in selecting the vehicle speed.	0.45 – 0.74
D	Ample traffic volume but still in the tolerable capacity of the road. Get close to irregular flow so that almost all drivers have limited vehicle speed.	0.75 –0.85
E	Excessive traffic volume in the maximum capacity of the road. The traffic flow is irregular with frequent stop of vehicle.	0.85 – 1.0
F	Induced traffic current or congested with very low speed vehicles. There will be long queue and immense constraints.	More than 1.0

Source: HCM (Highway Capacity Manual) in MKJI, 1997

Since traffic volume and road capacity are the essence of V/C ratio, both elements will be further elaborated in the following sections.

2.4.1 Traffic Volume

The traffic volume is the accumulation of the current of vehicle on the roadway. It consists of motorized and non-motorized vehicle. The quantification of traffic volume depends on the traffic composition in the area. According to classification system of Bina Marga in MKJI (1997), vehicles in Indonesia are categorized into several groups as follow:

1. Light Vehicle (LV);
   Including motorized vehicle with four wheels by means of two axis which the distance between is 2.0 – 3.0 m (e.g.: sedan, small pick up van and minivan). Private car is included in this category.

Figure 2.7 Type of Private Cars

2. Medium-Heavy Vehicle (MHV);
   Including motorized vehicle with more than four wheels (e.g.: bus, truck with either two or three axis).

Figure 2.8 Type of Medium-Heavy Vehicles

3. Motorcycle (MC);
   Including motorized vehicles with two or three wheels. There are two kinds of motorbike, two strokes and four strokes. Kojima et al. (2000) explained that if leaded gasoline is used, motorbikes with two-stroke engine will emit more organic lead to the ambient air than the one with four-stroke engine and even the cars.

Figure 2.9 Four-strokes motorbikes

4. Un-motorized (UM);
   Including vehicles which are run by man power and animal power (e.g.: bicycle, rikshaw and horse-carriage). In this case, UM is not being a part of traffic volume but it is considered as one factor of road side features (SF).

Figure 2.10 Rickshaw and Horse-drawn Carriage

In order to obtain the traffic volume data, a manual traffic counting method is employed on the field. Furthermore, the value of average vehicle speed and traffic density can also be acquired from the traffic field survey. However, to quantify the V/C ratio, the number of traffic volume must be standardized into the same unit of measurement using conversion factors (*emp*) based on the type of vehicles. The conversion factors for each type of vehicle are given as follows: *emp* of motorcycle = 0.5; *emp* of light vehicle = 1.0; *emp* of medium-heavy vehicle = 1.3; *emp* of light bus = 1.5; *emp* of light truck = 2.0.

2.4.2 Road Capacity

To assess the capacity of road properly, MKJI (1997) has classified the traffic facilities into six categories as follow:

1. Urban Arterial

   Urban arterial is characterized with perpetual and permanent development on all along or almost all along the left or/and right side of the road segment. It is usually located in a short distance to the city centre with more than 100,000 inhabitants. Road segment with population less than 100,000 inhabitants can be included in this category if only it has continuous permanent development along the roadside.

Figure 2.11 Road segment in Urban Area

2. Outer-urban Arterial

   Outer-urban arterial is characterized with no perpetual development along the roadside, even if there are some permanent constructions such as restaurant, factory and community neighborhood. It should be noted that small kiosk and booths are not categorized as permanent development.

Figure 2.12 Road Segment in Outer-urban Area
Source: www.roadtraffic-technology.com

3. Toll Way

   Toll way is usually built in urban area to contain enormous traffic demand of the population. It is characterized with free constraint in the driveway but it has limited means to all access.

Figure 2.13 Toll way in Urban Area
Source: www.ntta.org

4. Intersection with Traffic Signal

   Intersection is a facility to distribute the current of the traffic volume. It usually has three or four joints of road segment (see Figure 2.14). The functions of traffic signal are noted as follows:

(1) To avoid congestion of the opposite traffic currents so that the capacity of intersection can still be upheld in the peak hours.
(2) To reduce traffic accidents on the road such as collision of the different traffic flow. This happens usually because of the insufficient vision to the opposite traffic movements (e.g.: the vision is covered by building or/and vegetation).
(3) To help pedestrians to safely cross the street in the busy road.

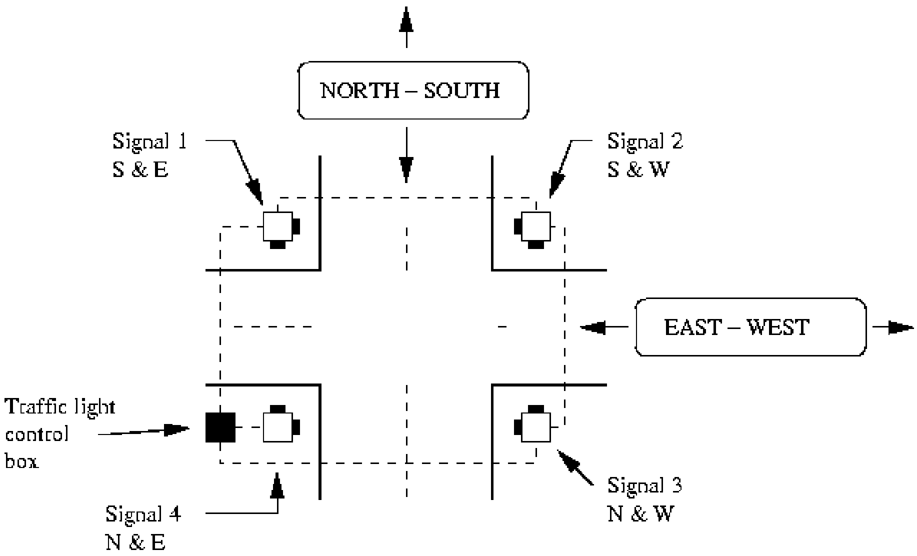


Figure 2.14 Four-legs Intersection with Traffic Signal
Source: www.isr.umd.edu

5. Intersection without Traffic Signal
   No traffic signal would be utilized on the intersection because the flow is still manageable. In a quite active intersection, traffic island may be employed as a replacement to the signal (see Figure 2.15).

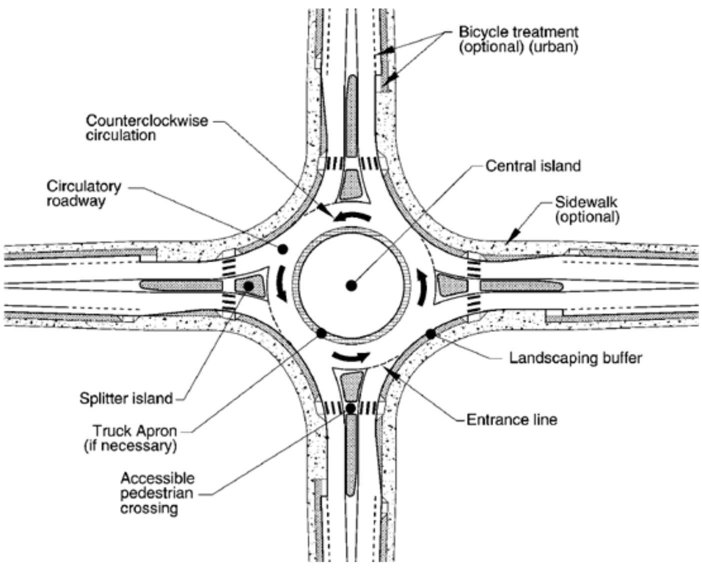


Figure 2.15 Four-legs Intersection without Traffic Signal
Source: www.hendrix.edu

Each of those facilities has its own formula to quantify its capacity. However, in regard to the objectives of the study, the focus of discussion will be narrowed down to the urban arterial and the intersection with traffic signal.

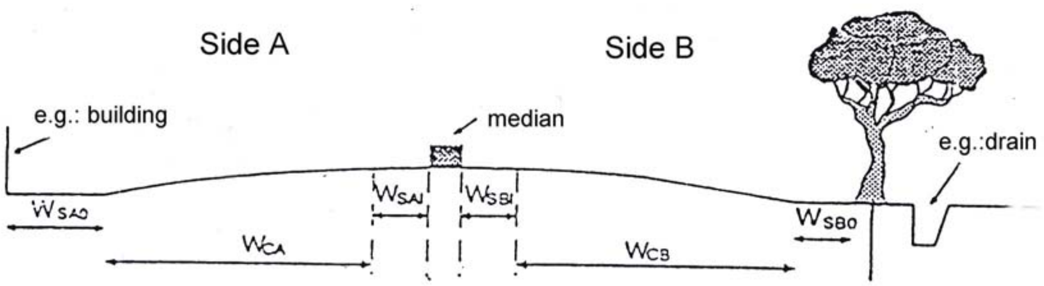
2.4.2.1 Urban Arterial

According to MKJI (1997), capacity and performance of urban arterial is influenced by several characteristics of the road segment as follow:

(a) Geometry;

It is including type of road segment; width of traffic corridor; street line divider; street shoulder; median; and street alignment. According to MKJI (1997), there are two types of road based on its geometry, with median (see Figure 2.16) and without median (see Figure 2.17).

- <u>Road section with median</u>



Source: MKJI, 1997

Note:

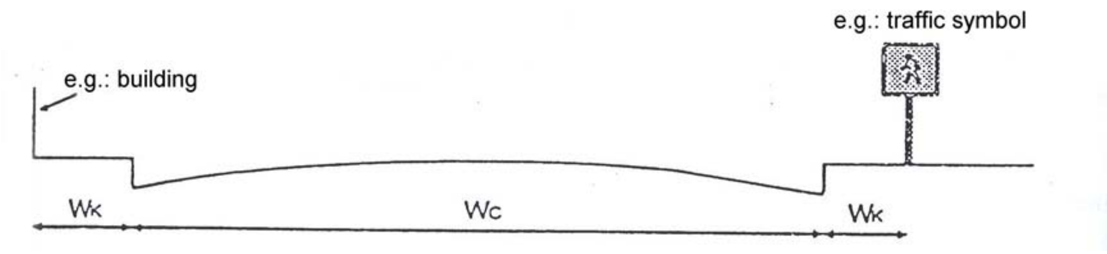
W_{CA}, W_{CB} = Width of traffic corridor

W_{SAI}, W_{SBI} = Width of inside shoulder

W_{SAO}, W_{SBO} = Width of outside shoulder

Figure 2.16 Geometry of road segment with shoulder and median

- <u>Road section without median</u>



Source: MKJI, 1997

Note:

W_C = Width of traffic corridor

W_K = Distance from shoulder to nearest road side features

Figure 2.17 Geometry of road segment with shoulder but without median

(b) Roadside Activity;

Many activities on the roadside may trigger some conflicts which have significant impact to the road capacity and service. In fact, this factor plays a greater deal in quantifying road capacity in Indonesia rather than in western countries. According to

Dishub DIY (2007) the roadside activities in Yogyakarta urban area which reduce the road capacity are as follows:

1. Roadside parking
2. The presence of un-motorized vehicle
3. The presence of small booth
4. The presence of infrastructure construction in the roadside

(c) Composition and Segregation of Traffic Current
(d) Traffic Control and Management
(e) Vehicle Population and Driving Behavior

Those characteristics are utilized, either directly or indirectly, to estimate the road capacity using math formula below:

$$\boxed{C = C_O \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS}}$$

where,

C = Capacity of road
C_O = Capacity origin
FC_W = Factor correction because of the width of the road segment
FC_{SP} = Factor correction because of segregation of street line
FC_{SF} = Factor correction because of the road side features
FC_{CS} = Factor correction because of the city size

Note: *In urban area this correction factors is given as follows*: $FC_W = 1.34$; $FC_{SP} = 1$; $FC_{SF} = 0.73$; $FC_{CS} = 1$

2.4.2.2 Intersection with Traffic Signal

According to MKJI (1997), capacity of intersection with traffic signal is principally gauged from the geometrical condition and traffic demand. The traffic demand is influenced by two types of traffic current, Opposed Current (O) and Protected Current (P) (see Figure 2.18).

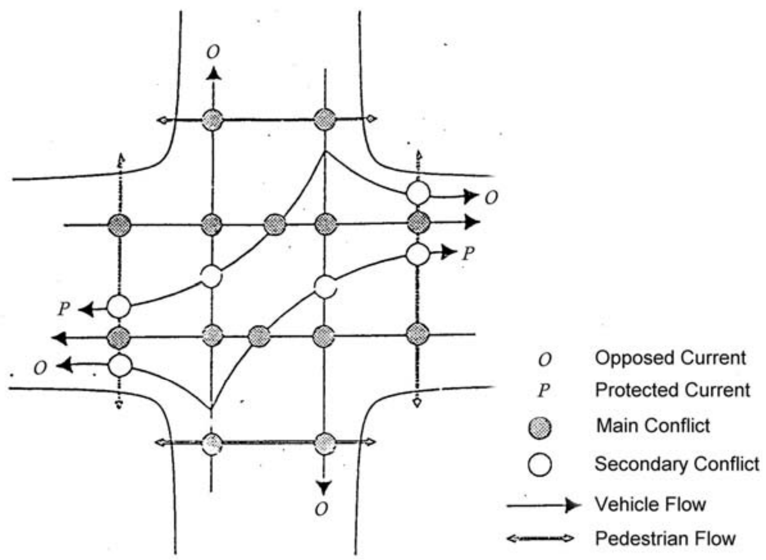


Figure 2.18 The Potential Conflicts in Four-legs Intersection
Source: MKJI, 1997

From Figure 2.18, it can be observed that the two currents will raise potential conflicts which may decrease the intersection capacity. In order to achieve the optimum capacity, these potential conflicts should be reduced and/or eliminated. The procedure to calculate the capacity of the intersection is described consecutively as follows:

1. Step A : DATA INPUT
   - A – 1 : Geometrical characteristics, traffic arrangement and site condition
   - A – 2 : Traffic current condition

2. Step B : TRAFFIC SIGNAL SELECTION
   - B – 1 : Signal phase arrangement
   - B – 2 : The intermission green light and the loss time interval

3. Step C : ESTABLISHMENT OF SIGNAL INTERVAL
   - C – 1 : Type of traffic current
   - C – 2 : Effective leg width of the departing current
   - C – 3 : Quantity of the departing current in one leg during the green signal period
   - C – 4 : Correction factors
   - C – 5 : Ratio between quantity of the traffic current and quantity of the departing current
   - C – 6 : Complete signal cycle period and green signal period

4. Step D : CAPACITY
   - D – 1 : Capacity
   - D – 2 : Necessary factor to change

The traffic volume (V) and road capacity (C) are acquired by traffic counting and field observation method using particular form sheets to avoid complicated efforts to capture all variables for each parameter in the study area. The specified form sheets are provided in MKJI (1997) which will be used in Traffic Counting to acquire the figure of V/C ratio.

2.5 Ambient Lead Pollution

According to the US EPA (2006), lead (Pb) is one of particulate matters on the ambient air whose diameter smaller than or equal to ten micrometers (PM_{10} or less) that can easily be inhaled by human being. In the fuel and energy sector, lead is added to the gasoline in the form of organic compound (tetraethyl-Pb or tetramethyl-Pb) as much as 2.4gr/gallon to improve the combustion characteristics (Tugaswati, 1999; Kojima et al., 2000; KLH, 2006).

Until late ’60s, lead additives in gasoline were still popular in every country around the world. In early ’70s, the invention of catalytic converter in automobile industry to reduce up to 80% carbon emission from the engine combustion had initiated people to alleviate the use of lead additives. The lead additives in the gasoline will make the catalytic converter malfunctioned because the lead micro-particles emitted from combustion will clog up the filter inside (KPBB, 1999).

Kusnoputranto (1999) explained that 70% of the lead compound in the gasoline will be emitted to the ambient air from the engine combustion. The particles will retain on the air for 4 to 40 days and will be spread out into soil, vegetation and the atmosphere on the range of 100 to 1000 km due to the intensity of the road traffic (KLH, 2006). The distribution of lead pollutant on the roadside is shown in Figure 2.19 below.

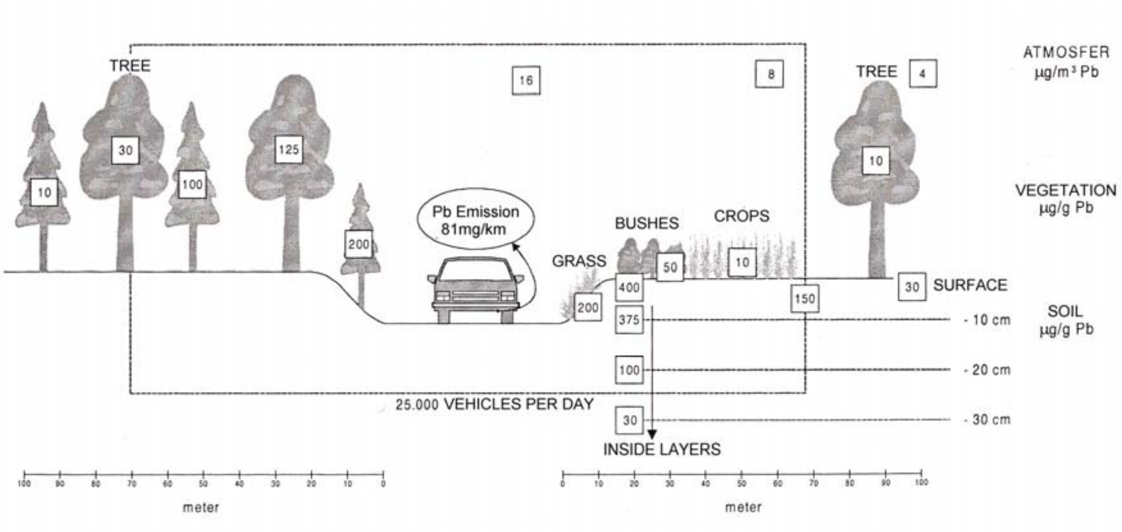


Figure 2.19 Distribution of Lead Emission on the Roadside by Smith (1976)
Source: Fandeli et al., 2004; pp 45

In Figure 2.19, Smith (1976) explained that the Pb emission level on the roadside depends on the traffic volume, distance to the pollution source, vegetation's crown density and even the soil to grow the tree (Smith, 1976 in Fandeli et al., 2004; WHO, 1989). In 1991, Fakuara has found that the most effective part to adsorb the Pb particles is the tree bark, although the structure of tree leaves also eminent (Fakuara, 1991 in Fandeli et al., 2004).

According to WHO (1989), lead level in plants and animal in area close to roads are positively correlated with traffic volume and proximity of roads. Lead concentrations are found highest in organism close to the road where the traffic density is high because lead tends to localize near the points of discharge. Most lead deposited is found within 500m of the road and within the upper few centimeters of soil. It is assumed that vehicular lead emission will not influence the ambient lead level at distances from road greater than this. And according to WHO (1989), lead level in organisms decreases exponentially with the distance from the road.

Hendrianty (2003) studied the distribution of vehicular lead emission on the leaves of Mahogani trees at subsequent distances from the roadway (50m, 100m and 300m) in Yogyakarta City. Using regression analysis, the result showed that the highest Pb level was found at the distance 50m from the roadway. Hendrianty assumed that the Pb risk-free location of housing and settlements should be more than 300m away from the roadway. To have better understanding to the adverse effects of lead pollutant, it will be discussed in the following section.

2.5.1 Adverse Effects and Level Standard of the Ambient Lead

Lead does not cause any damage to the built up features, however, it has neurotoxin character which brings significant accumulative effect into plants, animal and human body, which is much more harmful than the inorganic lead formed by the full combustion of lead additives (US EPA, 2007a; Kojima et al., 2000). Over-exposure to Pb pollutant regularly may cause adverse effect particularly to hemoglobin synthesis and in neurotics system such as disruption to growth, difficulties to concentrate, high risk to get encephalopitia and digestive illness, as well as diminution of intelligence quotient (IQ) (Marshal et al., 2005; ADB, 2006). According to the World Bank report in 1994, every 1 $\mu g/m^3$ increase to ambient Pb level will diminish the IQ score as much as 0.975 point in a year. Moreover, Marshal et al. (2005) noted that together with other particulate matters, lead particles have the potential of carcinogenic effect such as leukemia. Pb particles will accumulate in the blood, bones, muscles, and fat of any living creatures. The worst issue is that young children and infants are the most susceptible to the Pb toxicity effects since their anatomy system is more sensitive than the adults' (US EPA, 2007a). Tugaswati (1999) noted that it can even infiltrate the placenta and disrupt the fetus development. The adverse effects of lead accumulation in will be illustrated in Figure 2.20.

Damages organs - Lead causes damage to the kidneys, liver, brain and nerves, and other organs. Exposure to lead may also lead to osteoporosis (brittle bone disease) and reproductive disorders.

Affects the brain and nerves - Excessive exposure to lead causes seizures, mental retardation, behavioral disorders, memory problems, and mood changes. Low levels of lead damage the brain and nerves in fetuses and young children, resulting in learning deficits and lowered IQ.

Affects the heart and blood - Lead exposure causes high blood pressure and increases heart disease, especially in men. Lead exposure may also lead to anemia, or *weak blood.*

Affects animals and plants - Wild and domestic animals can ingest lead while grazing. They experience the same kind of effects as people who are exposed to lead. Low concentrations of lead can slow down vegetation growth near industrial facilities.

Affects fish - Lead can enter water systems through runoff and from sewage and industrial waste streams. Elevated levels of lead in the water can cause reproductive damage in some aquatic life and cause blood and neurological changes in fish and other animals that live there.

Figure 2.20 The adverse effects of Pb pollutant to human, animals and plants
Source: US EPA, 2007a

Kusnoputranto (1999) reported that among the ASEAN countries, Indonesia is the only one has not completely eradicated the use of lead additive in the gasoline yet. Although the unleaded gasoline has been widely distributed since 1995, the quantity is far below the fuel demand and its price is 30% higher than the leaded one. Thus, only few people switched to unleaded gasoline. This trivial number would not bring any significant contribution to the efforts to control the air pollution. Along with the rapid growth of motor vehicles, the use of gasoline will also increase 6% to 8% every year. The excessive consumption of gasoline will increase the intensity of Pb pollutant on the ambient air, thus also increase the risk of its adverse effect to human health.

In order to avoid the adverse effects, the ambient lead level standard needs to be established. The level is varied for each country depending on the case study (US EPA, 2007b). The US EPA promulgated a 1.5 µg/m^3 Pb National Ambient Air Quality Standards (NAAQS) for USA in 1978. Meanwhile, according to Government Directives (PP) No.41/1999, the standard for ambient Pb level in cities of Indonesia is 2µg/m^3.

In 1991, study in Jakarta showed that people dwelled close to heavy traffic had quite high blood-Pb level 0.3mg/ℓ for maximum average 0.15mg/ℓ (Kusnoputranto, 1999). Soetomo et al. (1999) examined that in Yogyakarta City, the Pb-blood concentration of street users is twice higher than those of who are not. Moreover, Soetomo et al. (1999) also noted that among 200 respondents, only few were aware of the accumulative effect of having Pb pollutant in the blood. Irwansyah et al. (2003) noted that even if the average ambient Pb concentration in Yogyakarta City is 0.1427µg/m^3, he had randomly examined Pb concentration in the urine of 40 respondents and found 77.5% of them had over limit blood-Pb level. These findings should urge the government, policy makers and urban planners to take environmental issue into serious consideration in development.

2.6 Urban Green Area and Ambient Lead Pollution

As it is aforementioned, green space is one significant entity in urban land development. Along with the environmental deterioration in urbanized area, the provision of green area is becoming urgent. In late ’80s, the essential of urban green space had already been legitimated by-law of the Ministry of Home Affairs in Ministry Instruction No.14/1988. According to the ministry instruction, urban green area is defined as the vacant space in the urban area which is barely open out without any built up entity within thus can be filled up with vegetation.

The advantages of urban green area is crucial for the quality life of the population as well as the urban environment. Based on its purpose, the green space in urban area is classified into several types as follows: (1) Urban park; (2) Urban forest; (3) Urban recreation area; (4) Sports field; (5) Graveyard; (6) Croplands; (7) Greenbelt; (8) House yard.

In regards to the ambient air pollution on the roadside, greenbelt is the appropriate category to put in practice because the vegetation along the roadside have considerable potential to absorb and hold the particulate matters, particulary the Pb particles (Smith, 1976 in Fandeli et al., 2004) thus it may reduce the risk of Pb toxicity of the street users.

In 1991, Fakuara et al. had studied about the Pb particles containment in various types of vegetation due to vehicular emission on the roadside (Fakuara et al., 1991 in Fandeli et al., 2004). The result showed that the vegetation capability to absorb and hold the Pb particles is mostly subjected to the coarseness of the tree bark, although the leaf size is also influential. Then, Fandeli et al. (2004) has set the criteria for greenbelt vegetation which is noted as follows:

1. The tree should have semi-dense to dense leaves composition which mainly green colored and its root should not spoil the infrastructure construction.
2. The tree may have various growth rapidity
3. The tree should be from such kind of annual crops
4. The tree can be indigenous plants or beneficial plants
5. The planting interval can be semi-compact to compact until it covers 90% of the total greenbelt area.

Based on the study of Fakuara et al. (1991), Fandeli et al. (2004) recommended five effective trees for the greenbelt along the road which will be consecutively illustrated as follows:

1. *Cassia seamea*

Figure 2.21 *Cassia seamea* and Its Leaves Structure

2. *Pithecellobium dulce*

Figure 2.22 *Pithecellobium dulce* and Its Leaves Composition

3. *Filicium decipiens*

Figure 2.23 *Filicium decipiens* and Its Leaves Structure

4. *Swietenia mahogany*

Figure 2.24 *Swietenia mahogany*, Its Bark and Leaves Structure

5. *Polyalthia longifolia*

Figure 2.25 *Polyalthia longifolia* and Its Leaves Structure

2.7 Land Use Change, Transport and Ambient Lead Pollution

The unguided development has triggered massive land use change and created leap frog structure to the northern part of Yogyakarta City because of the upper-middle class urban lifestyle triggered by the presence of two prestigious universities in Klaiurang Street Corridor (Rachmawati et al., 2004). Almost 75% of the students of these universities are coming from high-class family background thus it created high-class student's lifestyle environment along the street. The city has expanded to the suburbs, altered a number of productive lands into pavement and buildings. The remoteness to the city has created higher travel needs which raise the number of private vehicles since public transport is not adequately provided. Ammari (2005) observed that motorbike is the most favorable vehicle since it is affordable and convenient for personal transport within the city area. Undesirably, most of the motorized vehicles are using leaded gasoline which is still widely distributed in Yogyakarta urban area.

Moreover, the vivacity has not been followed by appropriate planning and tends to ignore the environmental consideration. Lack of land use and transport management and planning has lead to uncontrolled development that brings potential adverse effect to the environment and human welfare. The ambient air monitoring in Yogyakarta urban area from 2001 to 2006 has recorded there has been a trend of increasing Pb-level in the ambient air in several monitoring spots especially in the congested area.

However, in regard to the environmental sustainability issue, in April 2005, the government of Indonesia, supported by the ADB, has initiated “Urban Air Quality Improvement – Sector Development Program” (UAQ-i SDP). Yogyakarta City is one of the city participants that receive technical and financial supports to formulate the Local Strategy and Action Plan (LSAP) to improve the ambient air quality in the urban area. In the LSAP, there are five core strategies to deal with air pollution:

1. *Prevention Strategy*; A strategy to reduce the effects of direct/indirect factors that may trigger air pollution in urban area with solid public participation, such as:
   (a) To set out on planned and controlled urbanization process
   (b) To have ideal proportion in urban land use allocation
   (c) To raise people’s responsiveness in using motorized vehicles
   (d) To promote the use of environmental friendly fuel/ cleaner fuel
   (e) To encourage public involvement in preventing the air pollution

2. *Controlling Strategy*; A strategy to reduce emission load from any source to the air such as:
   (a) To improve the fuel quality
   (b) To set the standard emission factor from mobile source
   (c) To enforce the implementation of standard emission from point source
   (d) To enhance the transportation management
   (e) To improve and enhance the facility and service of public transportation system
   (f) To provide facility that encourage the use of non-motorized vehicles
   (g) To encourage car-pooling system
   (h) To manage the solid waste
   (i) To control the indoor air pollution

3. *Monitoring Strategy*; A strategy to measure the pollutant concentration in the ambient air regularly in order to provide data and information about air pollution and its impact to the environment and human health such as:
   (a) To enhance the ambient air monitoring system
   (b) To support regional air quality monitoring system
   (c) To improve the continuous availability on emission data base inventory
   (d) To develop air quality prediction method
   (e) To enhance the spread of air quality information regularly

4. *Mitigation Strategy*; A comprehensive strategy to investigate and quantify air pollution and its impact in order to alleviate the adverse effect to the environment and human health.
   (a) To enhance the monitoring system and mitigation measure of adverse effect to human health
   (b) To enhance the monitoring of the impact to vegetation
   (c) To enhance the monitoring of the impact to building and historical building
   (d) To assess the air pollution impact economically
   (e) To reduce the air pollutant in order to reduce GHG effects

5. *Institutional Strategy*; A strategy to strengthen the performance of government agencies and related institutions to deal with air pollution issues such as:
   (a) To enhance the capacity and coordination among APY Joint Secretariat to improve urban air quality
   (b) To synchronize regulation and compilation of various technical guidance
   (c) To implement law enforcement
   (d) To enhance the capacity of local human resources
   (e) To prepare financial balance for Air Pollution Management Program

Based on the strategies mentioned above, there are many aspects influencing the air pollution issue, as represented in Table 2.10.

Table 2.10 The Indicator for Better Air Quality in Yogyakarta Province

Yogyakarta Provincial Indicator for Better Air Quality				
Preventing	**Controlling**	**Monitoring**	**Mitigation**	**Institutional**
1. Development control 2. Land use allocation 3. Travel behavior 4. Clean fuel 5. Public participation	1. Clean fuel 2. Standard emission 3. Transportation management 4. Public transportation 5. Non-motorized vehicle 6. Car-pooling system 7. SWM 8. Indoor air pollution	1. Ambient monitoring system 2. Emission data base inventory 3. Air quality prediction method 4. Information about air quality	1. Adverse effect to human being 2. Impact to vegetation 3. Impact to built environment 4. Economic value of adverse impact 5. GHG effect	1. Capacity building 2. Coordination 3. Regulation and enforcement 4. Technical guidance 5. Fund raising for Air Pollution Management Program

Source: Developed from ADB, 2006

Table 2.10 shows that land use allocation and transport management are two components of many parameters in use to assess the air quality. Based on the strategies, this study will try to perceive the correlation of land use change and transport to the ambient lead pollution using statistical analysis. In order to follow the statistical analysis requirements, rectified variable for each parameter should be set properly.

Referring to the previous studies and the reviewed theories, there are many variables and methods to seek the correlation of land use and transport to the ambient-Pb level. However, due to a number of limitations, only a number of parameters will be employed to obtain the cross-sectional data for describing the correlation of land use change and traffic characteristics to ambient-Pb level. Then, multiple linear-regressions is utilized in this study as the simplest yet relevant analysis method. The parameters of land use change and transport are assigned as the independent variables assumed having correlation to ambient-Pb level as the dependent variable. The regression method will verify the assumed correlation and perceive the magnitude of the correlation.

The land use and transport's parameters from the reviewed literature is listed in Table 2.11 and then selected using purposive selection method based on the criteria as follows:

1. The interrelationship should be supported by the reviewed theories and previous studies.

2. It should be in accordance with the previous data base inventory of the relevant institution in the study area.
3. It should be suitable and feasible in local condition.
4. It should be quantifiable and collectable within the allocated time and financial resources of the study.

Table 2.11 Land Use and Transportation Parameters

VARIABLE	PARAMETER	ASSUMED CORRELATION TO AMBIENT LEAD LEVEL	DESCRIPTION
Land Use	**Building Density***	(+)	The land use change from croplands into built up area has triggered more travel generation which also increase vehicular emission to the ambient air (Roelofs, 1996).
	Roadside Vegetation*	(-)	Roadside vegetation is vegetation's crown density that will adsorb the Pb particles from vehicular emission (Smith, 1976 in Fandeli, 2004). Hendrianty (2003) explained the highest adsorbing capacity is at 50m from the roadway.
	Type of Vegetation	(-)	Type of vegetation that may have effective adsorption capacity to Pb-particles is characterized from its bark and its leaves structure (Hendrianty, 2003; Fakuara, 1991 in Fandeli et al., 2004).
	Soil and/or Sedimentation	(-)	WHO (1989) has found that soil and sedimentation may also adsorb the roadside Pb-emission. The adsorption capacity depends on the area size and the coarseness of the material.
Transportation	**V/C Ratio***	(+)	The level of congestion is quantified by V/C ratio. The increase number of V/C ratio means the level of congestion is also increasing which will impinge on the increase of vehicular emission from incomplete engine combustion (Dishub DIY, 2005; 2006).
	Travel Speed*	(-)	Vehicle speed shows the vehicle's engine operation. The idle and decelerated engine operation will increase the vehicular emission from incomplete engine combustion (Kojima et al., 2000; Stopher and Fu, 1998).
	Traffic Density*	(+)	Traffic density is the number of vehicle in motion per square meter roadways in certain period of time. The more intense traffic activity will increase vehicular emission to the ambient air (Warpani, 2002; Stopher and Fu, 1998).
	Vehicle Meter Traveled	(+)	Vehicle meter traveled (VMT) is indicating the amount of distance traveled by one vehicle. Since leaded gasoline is still in use, the high number of VMT will raise the Pb-emission rate to the ambient air (Stopher and Fu, 1998)

	Vehicle Time Traveled	**(+)**	Vehicle time traveled (VTT) is indicating the amount of time traveled by one vehicle. Since leaded gasoline is still in use, the high number of VTT will raise the Pb-emission rate to the ambient air (Stopher and Fu, 1998)
	Engine Characteristics	**(-)**	The characteristics of engine will affect the combustion performance. Kojima et al. (2000) found that for motorbikes, the two-stroke engine is emitting more Pb than the four-stroke engine, even more than car using leaded gasoline as well.
	Fuel Characteristics	**(+)**	The fuel characteristic is the most pertinent factors in affecting vehicular emission to the ambient air. Since most gasoline distributed in Yogyakarta City is still using lead additives (ADB, 2006), it is assumed that 95% of the motorized vehicles are using that fuel (DISHUB, 2007).

Note: Bolded parameters with asterisk (*) are variables in use for statistical analysis in this study

Chapter 3

Research Design and Methods

This chapter will discuss the methods and procedure to answer the objectives of the research. First the discussion will start from the methods being employed throughout the study. It is followed by brief introduction to the research location and the selection of study area. Then, it is continued with the discussion on the methods of data gathering and analysis.

3.1 Research Methods

There are three methods in the realm of scientific research which are Qualitative, Quantitative and Mixed Methods. The characteristics of each research method will be presented in Table 3.1 below.

Table 3.1 The Research Methods and Its Characteristics

Qualitative Method	Quantitative Method	Mixed Methods
Characteristics: ▪ Predetermined ▪ Instrument based questions performance data ▪ Observation data and census data ▪ Statistical Analysis	**Characteristics:** ▪ Emerging methods ▪ Open ended questions ▪ Interview data ▪ Observation data ▪ Document data and audiovisual data ▪ Text and image analysis	**Characteristics:** ▪ Both predetermined and emerging methods ▪ Both open and closed-ended questions ▪ Multiple forms of data ▪ Statistical and text analysis
Objective: Descriptive and explanatory result of the collected data.	**Objective:** Statistical and image approach for analyzing the collected data	**Objective:** Using both descriptive and statistic method to explain the research objective

Source: Developed from Adamantios, 1997in Wongbumru, 2005

In order to achieve the objectives of this study, it is crucial to collect various kind of information for the analysis. Collecting various information requires different kind of methods, thus the study will employ the mixed research method which is described as follows:

1. ***Qualitative Method*** will be used for acquiring the general information of the land use development and the change from 1997 to 2007 and the state of air quality in the study area. This method is used to identify the driving force and characteristics of land use pattern in the study area and the condition of transportation and the trend of the air quality.
2. ***Quantitative Method*** will be used for describing the correlation of land use and transport variables to the ambient Pb level acquiring the specific data by conducting the sampling survey for transport and ambient lead level data as well as using GIS applications for land use changes analysis. Multiple regression analysis method is utilized in order to seek the correlation among the three variables.
3. ***Mixed method*** will be used for the final analysis which is involving regression analysis, map interpretation and ground truth observation in order to describe the correlation of land use change, transport and the ambient lead level in the study area.

3.2 Introduction to Research Location

Yogyakarta City is the capital of Yogyakarta Special Region (DIY) Province in Central Java, Indonesia. The province covers 3.186 km^2 with 3.178.698 registered populations (Population Census, 2000) distributed to 5 regions namely Yogyakarta City, Sleman Regency, Bantul Regency, Kulonprogo Regency, and Gunung Kidul Regency (see Figure 3.1) elevated from ± 50m to ± 200m above mean sea level.

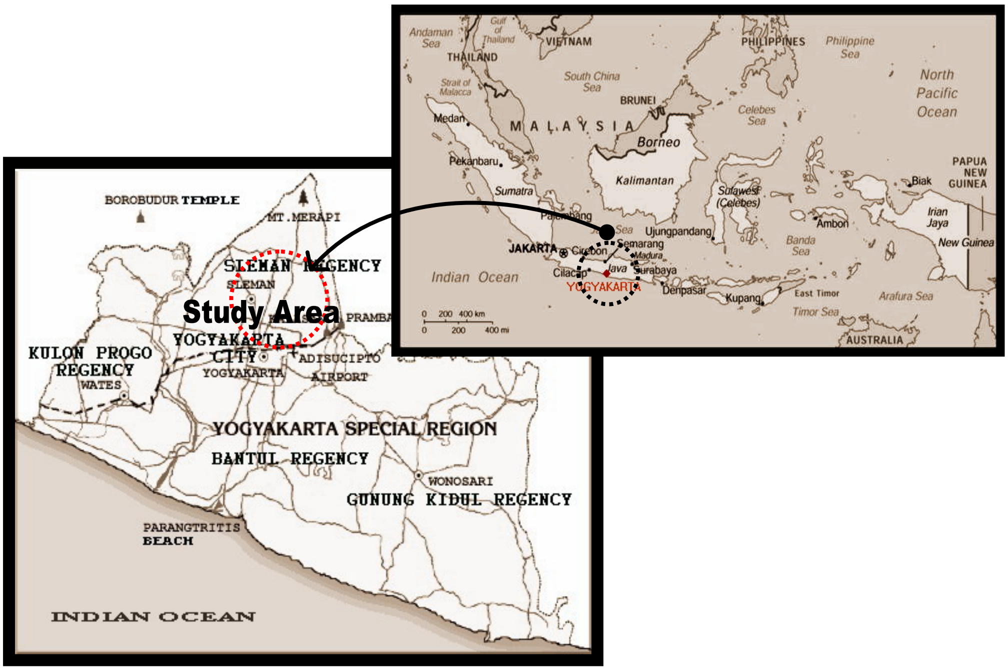


Figure 3.1 Map of Yogyakarta Special Region (DIY) Province
Source: www.1uptravel.com

Geographically, the province is located in the volcanic foot plain of Mountain Merapi in the northern part and growing in the linear axis to the south until it meets the Indian Ocean. Both, Mountain Merapi and the Indian Ocean, impinge on the topography, soil type and local climate of Yogyakarta City and its vicinity. The slope is going down from the north to the south dominated by flat terrain with inclination class 0-2%. The soil is dominated by *regosol* type which is very good for rice and crops cultivation. The city has tropical climate with temperature around 22°C-34°C and average humidity 24.7% which created comfortable surroundings.

Administratively, Yogyakarta City only covers 32.8 km² areas with average population density 15.197/km^2 in early 2000. It used to be the capital of Indonesia during the Indonesian Revolution from 1945 to 1949, where the central government built the first university, Gadjah Mada University (UGM). It becomes the oldest and one of few most prestigious universities in Indonesia.

Today, there are 58 institutions equal to university level which will receive more than 10.000 new students every year. Most of the institutions are located in the urban fringe and trigger the sub urban sprawl around the city. This has created the expansion of the city to the fringe area and formed new jurisdiction area called Yogyakarta Urban Agglomeration (APY) area. It covers the total administrative area of 14 districts in Yogyakarta City, 9 districts in Sleman Regency in the northern part and 5 districts in Bantul Regency in the southern part. The APY area is administered by a special agency namely Joint Secretariat of KARTAMANTUL, consists of official representatives from the three regions. However, there are still many conflicting issues involved in practice.

To date, the education and tourism service industries have not only triggered more intensive use in land in the suburb but also have been invigorating the land value in APY area (Basuki, 1993; Setiawan, 1993; Rachmawati et al., 2004; Harini et al., 2005; and Kurniawan, 2005). In some strategic locations close to universities, the land price has been sky-rocketting. This phenomenon is influencing the commitment of the farmers to their agricultural lands and activities in the urban fringe areas (Yunus, 2003). They have been economically motivated to give up the land. The local government of Yogyakarta City has no instrument to control the land price in the urban fringe areas, thus it is difficult to implement the land use zoning (Yunus, 2002) which is resulting in the leap frog development in the study area (Figure 3.2).

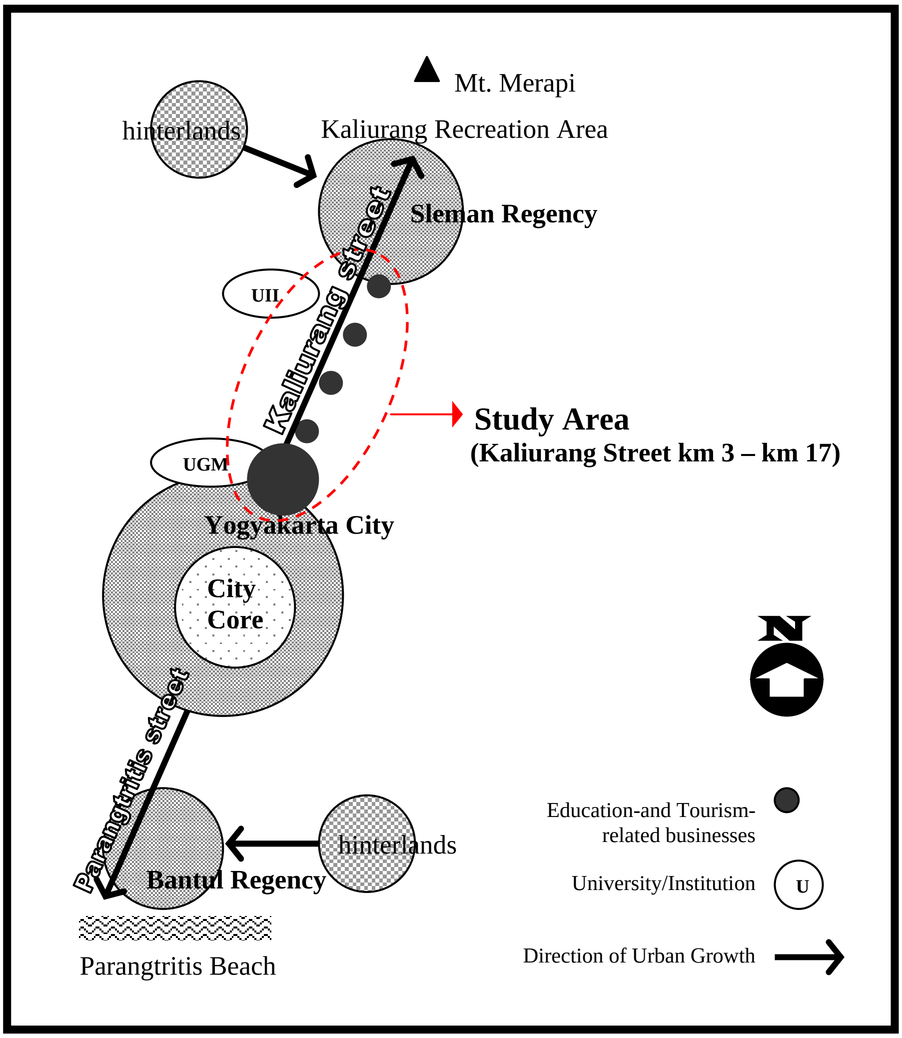


Figure 3.2 Current Developments in Yogyakarta City and Its Vicinity
Source: Developed from studies of Yunus (2002; 2003), Rachmawati et al. (2004), Rachmawati and Kurniawan (2006)

The foundation of UII campus in 1990 in Kaliurang street km 14 has been identified as the driving force of rapid development to the northern fringe. Before, UII was located in the city core. As it has been well-developed and needed more space, UII moved its main campus to Kaliurang street km 14. UII has been famous for the campus for middle-upper class students, thus it triggers the development of high-class lifestyle environment along the Kaliurang street corridors. This was proved by the occurrence of massive conversion from agricultural to non agricultural lands from 1992 to 2002 in the northern fringe (Yunus, 2003).

3.2.1 Selection of Study Area

The study area is a 15 km of urban arterial called Kaliurang Street which is connecting two most prestigious universities in the northern suburbs of the city, Gadjah Mada University (UGM) in km 4 and Indonesian Islamic University (UII) in km 14. The street is smoothly constructed with asphalt which lays along three districts namely Depok, Ngaglik and Pakem located in the Sleman Regency, Yogyakarta Province. According to census survey in 2002, the total population in each district consecutively is 113,460 persons, 17,995 persons, and 2,002 persons. It has been chosen because of the following reasons:

a. Among 15 monitoring stations in Yogyakarta Urban Agglomeration area, only the monitoring station in Kaliurang area has recorded the 24-concentration of Pb was rapidly increasing and exceeding the emission standard in 2005 (BAPEDALDA, 2004 in ADB, 2006).
b. The rate of population growth in the study area is the fastest among all districts in APY area and the population density is high (SUSENAS 1980, 1990 and 2000 in ADB, 2006). As most population lives in that area, more people generate waste and more people may get the adverse effect to the contamination of the waste.
c. There has been a study shows that the fastest loss of agricultural lands occurs in the northern periphery in the proximity to the city (Yunus, 2003).
d. There are two prestigious universities located 10km away from each other on Kaliurang Street which triggers massive in-migration to the northern suburbs of Yogyakarta City (Rachmawati et al., 2004). The universities have been famous as the campus of middle-upper class students which create the high-class lifestyle environment along Kaliurang street corridor.
e. There was a massive land conversion from agricultural to non agricultural lands from 1992 to 2002 and the fastest loss of agricultural lands occurred in the northern fringe in the proximity to the city (Yunus, 2003)

3.2.2 Location of Study Area

In order to meet the statistical analysis method requirement, the study will occupy 15 sample points along Kaliurang street corridor which are determined as follow:

1. Point A : 4-junction of Mirota Kampus Supermarket (km 3)
2. Point B : 4-junction of MM UGM (km 4.5)
3. Point C : In front of Gading Mas Minimarket (km 5.2)
4. Point D : 4-junction of Kentungan (km 5.8)
5. Point E : In front of Tina Farma Drug Store (km 6.4)
6. Point F : In front of Colombo Market (km 6.7)
7. Point G : In front of PLN (Regional Power Plant) (km 7.8)
8. Point H : In front of Social Agency Book Store (km 8.5)
9. Point J : T-junction of Merapi View (km 9)
10. Point K : In front of Gentan Market (km 11)
11. Point L : In front of WS Minimarket (km 11.5)
12. Point M : In front of Toraja Sea Food Restaurant (km 13)
13. Point N : In front of UII Campus (km 14.2)
14. Point P : In front of Mirota Batik (km 15.7)
15. Point Q : T-junction of Pakem Market (km 17)

The points are enumerated by letters to avoid perplexity with the enumeration of statistical variables. A number of of the observation points have already been determined by the Provincial Environmental Impact Control Agency (Point A, B, D, E, F, J, N and Q) as well as the Provincial Transportation Bureau (Point B and G). In order to avoid mystification with numbers, letter ”I” and ”O” are omitted from the enumeration. The pictures of the sample points are attached in Appendix 1.

3.3 Research Procedure

Research procedure will explain about type of data, data gathering method and data analysis. Data is the most essential elements in research strategy. In deductive research, the purpose of data gathering is to corroborate the hypotheses. Thus reliability and validity of data must be adequately addressed to accomplish plausible result. In order to assure the achievement of the three objectives of the study, the required data is initially projected for each research objective, as represented in Table 3.2. The overall research framework for this study is presented in Appendix 24.

Table 3.2 Research Objectives and Projected Required Data

Research Objective	**Required Data**
1. To describe the characteristics of existing land use pattern due to land use changes and the driving forces of the changes in study area	❑ Records and report on land use changes from 1997 to 2007 ❑ Land Use Plan and Land Use Map of Sleman Municipality ❑ A set of questionnaire to government officials and urban experts who deal with land use planning. ❑ Informal interview with the old native dwellers.
2. To describe the state of transportation and ambient lead level due to the enormous growth of motorized vehicles in study area	❑ Transportation reports and records from 1997 to 2007. ❑ Informal interview with the officials from Provincial Transportation Bureau.
3. To describe the correlation among land use changes and transportation to ambient lead level	❑ Reports and records on parameters of each variable from relevant institution. ❑ Sampling data of: 1. Ambient lead level 2.a. Building density b. Roadside vegetation 3.a. Traffic volume b. Traffic density c. Average travel speed d. Roadside side feature e. V/C ratio

3.4 Type of Data

This study is using both primary and secondary data which are as follows:

1. Primary Data

The primary data are cross-sectional data required for verifying to what extent and in what way the correlation of land use and transport factors to the ambient lead level using multiple linear regression method. The data are collected by field sampling observation and using GIS Application to capture the land use feature from the latest satellite image in 15 sample points study area to fulfill the minimum statistical analysis requirement. The sample points are selected based on purposive sampling method. Furthermore, a set of questionnaire and informal interview is utilized to acquire information about the potential driving forces of land use change in the study area. The required data will be listed in Table 3.3.

Table 3.3 Primary Data and The Gathering Method

No.	Type of Data	Data Gathering Method
1	Ambient Lead Level	Ground sampling using High Volume Air Sampler (HVAS) by the Environmental and Health Protection Agency (BBTKL)
2	Building Density	Land use mapping to identify built up area from Quickbird Image 2005 and DigitalGlobe Image 2007 using GIS applications by PUSPICS Research Center, UGM
3	Roadside Vegetation	Land use mapping to identify roadside vegetation area from Quickbird Image 2005 and DigitalGlobe Image 2007 using GIS applications by PUSPICS Research Center, UGM
4	V/C Ratio	Traffic counting and field observation in the sampling area by the Provincial Transportation Bureau (Dishub DIY)
5	Traffic Density	Traffic counting and field observation in the sampling area by the Provincial Transportation Bureau (Dishub DIY)
6	Travel Speed	Speed simulation in the sampling points by the Provincial Transportation Bureau (Dishub DIY)
7	Driving Force of Land Use Change in Kaliurang street corridor	A set of questionnaire for the officials who deal with development and land use planning.

2. Secondary Data

The secondary data is required to focus on records and trend of the specific issues on the primary data for the comprehensive analysis. The data will be collected from the relevant institutions as well as informal interview with the officials and urban experts. The required data will be listed in Table 3.4.

Table 3.4 Secondary Data and Its Source

No.	Type of data	Data Source
1	▪ Policy, rule, regulation on air pollution, particularly Pb pollutant ▪ Reports on ambient Pb monitoring ▪ Air Quality Standard in Indonesia ▪ Strategies on air quality management	▪ Regional Environmental Impact Control Agency (BAPEDALDA) of Yogyakarta Province ▪ Office of Environmental Impact Control (KPDL) of Sleman Regency ▪ Regional Office of Ministry of Environment (KLH)
2	▪ Vehicle composition and vehicle growth in Sleman Regency from 1997 to 2007 ▪ Reports on traffic monitoring from 1997 to 2007	▪ Statistics Center Agency (BPS) of Yogyakarta Province ▪ Statistic Center Agency (BPS) of Sleman Regency ▪ Provincial Transportation Bureau (DISHUB)
3	▪ Environmental policy on urban green area ▪ Reports on the state of urban green area in Sleman Regency	▪ Regional Planning Agency (BAPEDA) of Yogyakarta Province ▪ Regional Environmental Impact Control Agency (BAPEDALDA) of Yogyakarta Province ▪ Regional Planning and Development Agency (BAPPEDA) of Sleman Regency ▪ Office of Environmental Impact Control (KPDL) of Sleman Regency
4	▪ Land use plan and policy at provincial level ▪ Land use plan and policy at local level ▪ Land use map of Yogyakarta Province ▪ Land use change growth in Sleman Regency	▪ Regional Planning Agency (BAPEDA) of Yogyakarta Province ▪ Regional Environmental Impact Control Agency (BAPEDALDA) of Yogyakarta Province ▪ National Land Use Planning Agency (BPPN) of Sleman Regency

3.5 Data Gathering Methods

This section provides ample discussion on the methods to collect each primary data with several conditions as follows:

1. All of the sampling surveys were done by the third parties who have the capacity to perform such course of action. This would also ensure reliability and validity of the data. Nevertheless, researcher was also in attendance when the sampling survey was conducted.
2. Stopher and Fu (1998) explained that estimation of emission rate should be done within the peak hours, not in the average day. According to transport survey by Dishub DIY (2005; 2006), the peak hours in Yogyakarta urban area is from 06.30 am to 08.30 am. Thus, all of the sampling surveys were done once for each point at that period.
3. Although WHO (1989) explained that the vicinity of lead emission is less than 500m from the roadway, Hendrianty (2003) found that in Yogyakarta City, the vicinity of lead emission is less than 300m from the roadway. BBTKL (2007) explained that with the presence of built up area, the locality of ambient Pb is 200m. Thus, the sampling point is set as a circular area with diameter 250m.

3.5.1 Ambient Pb Level

Figure 3.3 High Volume Air Sampler (HVAS)

To acquire the ambient Pb concentration, sampling survey to obtain specimen in each point was done using High Volume Air Sampler (HVAS) (see Figure 3.3) and then, the specimen was analyzed in the laboratory using ASTM D4185-96 test methods. The HVAS was set in the mid-point of the sampling area to catch a quantity of air as a specimen in the locality during one hour. The survey and analysis procedure was performed by proficient crews of Health and Environmental Engineering Agency (BBTKL) which is also assigned by Provincial Environmental Impact Control Agency (BAPEDALDA) to monitor the ambient air quality in Yogyakarta Province (DIY).

Some of the monitoring data of ambient-Pb level have been recorded by the Provincial Environmental Impact Control Agency in October 2007.

3.5.2 Land Use Mapping

Land use mapping was done to interpret the Quickbird Image 2005 and DigitalGlobe Image 2007 using GIS application to acquire the spatial and non-spatial data for the land use change analysis. The GIS application was operated in ArcView 3.2, the GIS software from Environmental Systems Research Institute (ESRI) and performed by skilled personals from PUSPICS Research Center of UGM which is a commercial agency for remote sensing technology and GIS application practice. The data input for land use mapping is only satellite image. In order to assure the reliability issue, the satellite image should be up to date and having fine pixel resolution. However, its availability in Indonesia is unpromising due to the financial and technology shortcoming. The latest image with fine resolution available in PUSPICS Research Centre is Quickbird Image 2005 (see Figure 3.4).

Disappointingly, the image has only half segment of the study area (from point A to point H), in consequence the rest of sampling location should be purchased from Regional Land Use Agency (BPPD) of Sleman Regency in affordable cost. However, the purchased image had no fine resolution, thus identification was impossible to carry out. Fortunately, the latest technology of internet has facilitated people to access and capture the earth sphere using satellite. It was found that the quality of the satellite image called DigitalGlobe Image from one reliable website source (Google Earth at http://earth.google.com) is better than the purchased image from BPPD. The comparison of both images is presented in Figure 3.5.

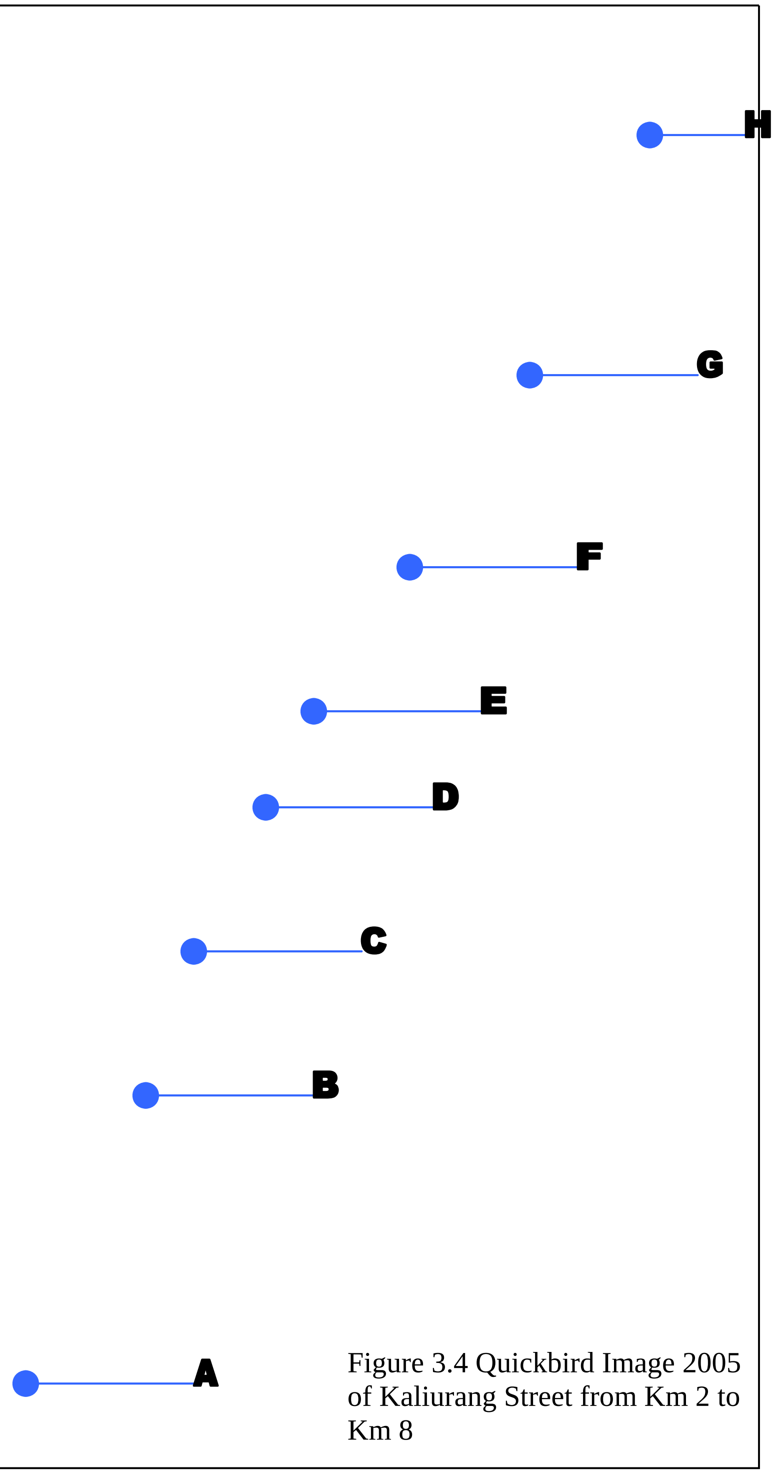
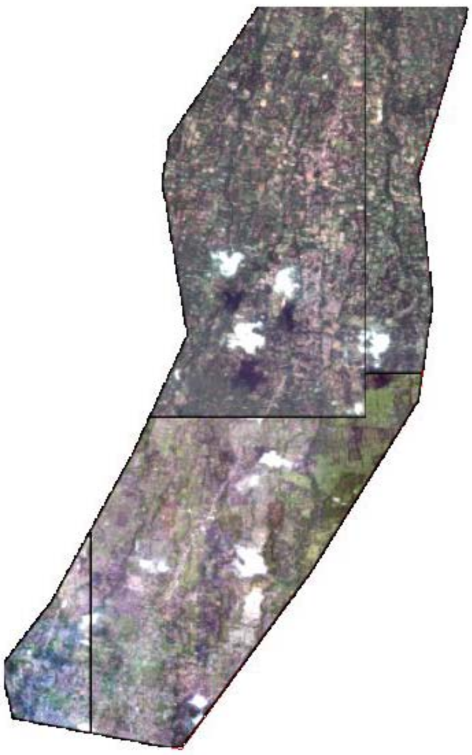
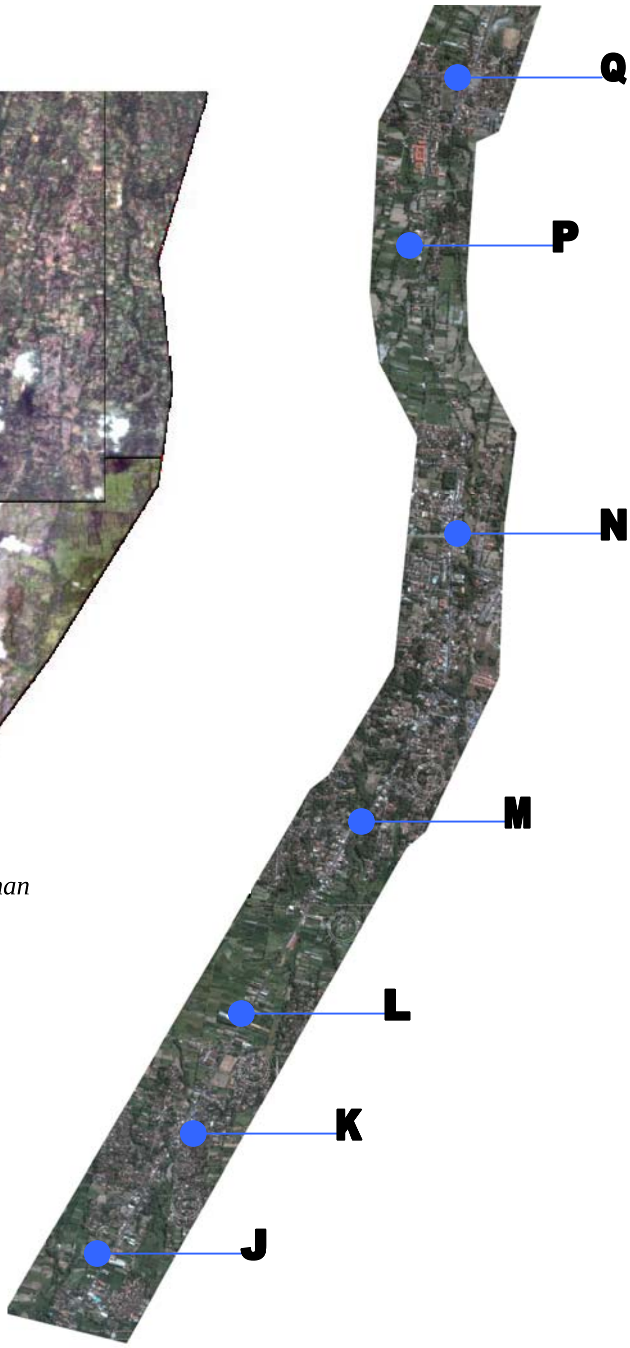


Figure 3.4 Quickbird Image 2005 of Kaliurang Street from Km 2 to Km 8

Due to the time and financial limitation, the satellite image of Kaliurang street km 8 to km 17 from internet was being utilized. In order to assure reliability, the image was registered into the same coordinate system with the Quickbird Image 2005 using tools in ArcView 3.2. Thus, both image can be blended and utilized as data input for land use mapping.



(a) Image from BPPD Sleman



(b) DigitalGlobe Image 2007

Figure 3.5 The Comparison of Satellite Image Resolution between BPPD Sleman Image and DigitalGlobe Image

The result of land use mapping is represented in vector data format. The identification of land use type was determined by researcher to meet the purpose of study along with the reference from reviewed literature which is listed as follows:

1. Building; includes all built up features in the image such as house, office and shop.
2. Road; includes urban arterial and local road but not neighborhood road.
3. Hard-manufactured feature; includes all paved area such as sport courtyard and sidewalks.
4. Vegetation below 1 m; includes all area which is planted with vegetation below 1 m tall such as croplands and ricefields.
5. Vegetation over 1 m; includes all area which is covered by the crown of the annual tree which follow the criteria set by Fandeli et al. (2004).

In order to acquire valid identification on the type of land use, it needs quite a skill to interpret the satellite image. Furthermore, to verify the image interpretation in each point, it is necessary to conduct the ground truth observation. This will be helpful to analyze the land use change phenomenon in the study area.

After the identification of each category has been done, the statistical figure of each category can be easily acquired in the descriptive information in ArcView 3.2. Building density is defined as percentage of the breadth of built up area per total breadth of the sampling point. Meanwhile, based on studies of Hendrianty (2003) and Fandeli et al. (2004), the statistical figure for roadside vegetation was obtained only from vegetation over 1 m tall which is located within 50m from the roadway,.

3.5.3 Traffic Counting and the Speed Simulation

The traffic counting was undertaken in each sampling location to collect the required data for calculating V/C ratio and the traffic density. Meanwhile, the speed simulation was conducted to obtain the vehicle speed in each sampling location. Both practices were performed by proficient crews from Provincial Transportation Bureau. Digital video camera was utilized to ensure validity of the field observation.

Traffic Counting

Traffic counting was performed to collect traffic data on the sampling location, including traffic volume (V) and road capacity (C), to acquire the figure of traffic density and V/C Ratio using the established forms from MKJI (1997). The traffic volume is defined as number of all type vehicles in motion per hour. In traffic counting, number of vehicles was counted in 15 minutes interval from 06.30 am to 08.00 am, and then the lowest two was dropped off to obtain number of vehicle in motion per hour. However, it should be noted that each type of vehicle uses up a different size of space to move. Thus, each type of vehicle was converted using equivalent coefficients (emp) to standardized the calculation for traffic volume. The collected data for traffic volume will also describe the traffic composition in the study area.

The traffic density in this study is defined as the number of vehicles with leaded gasoline (LV and MC types) per square meter of Kaliurang street in sampling location. It is calculated using the collected data from traffic counting.

Meanwhile, the required data for road capacity was obtained by field observation. The observation was aimed to quantify the breadth of the road and the roadside activity which may decrease the capacity of the road in each sampling location. All the procedure for calculating both variables is available in *Manual Kapasitas Jalan Indonesia* (MKJI) 1997, the manual for road capacity management in Indonesia.

Speed Simulation
Speed is rooted from distance (m) and time (s). The distance is known as the diameter of the sampling point. The time is obtained from speed simulation. The simulation was conducted by recording the vehicle's time traveled to pass the sampling point using stopwatch in each traffic counting period. The lowest figure of vehicle's time traveled is taken to calculate the vehicle speed in the sampling location.

3.5.4 Questionnaire of Driving Forces of Land Use Change
The questionnaire is utilized to verify the driving forces of land use change in Kaliurang Street Corridor. In order to ensure reliability and validity, the questionnaire is distributed among 15 officials and representatives from relevant institutions which deal with development and land use planning in Yogyakarta Urban Area.

3.6 Data Analysis
In order to answer the central research question, the objectives of the research are addressed consecutively in one solitary chapter. The discussion begins with the qualitative descriptive of each parameter which includes the information from secondary data collection and then verified quantitatively using multiple linear-regressions technique. Regression analysis will be utilized to corroborate the assumed correlation of land use and transport to the ambient Pb level due to urban sprawl phenomenon in Yogyakarta Urban Area and describe to what extent and in what ways the correlation is presence.

Chapter 4

Land Use Changes

In order to address the first research objective, this chapter provides discussion on land use changes analysis including the driving forces in the northern fringe of Yogyakarta Urban Area, particularly in three districts along Kaliurang Street Corridor, Depok District, Ngaglik District and Pakem District of Sleman Regency.

4.1 Demographic Profile

The statistical records showed that from 1997 to 2006 the number of population in Depok, Ngaglik and Pakem District has been steadily increasing (see Table 4.1).

Table 4.1 Demographic Profile of of Depok, Ngaglik and Pakem District, 1997 – 2006

Demographic Profile	Depok				Ngaglik				Pakem			
	1997	2000	2003	2006	1997	2000	2003	2006	1997	2000	2003	2006
Population (person)	102978	109092	115109	180243	62271	65937	70050	84847	29752	30713	31868	31905
Annual Growth (%)	1.75	2.21	1.45	51.63	1.37	2.15	1.86	16.47	0.71	1.53	1.15	1.06
Number of Household	22797	26034	29393	32174*	15116	16588	18519	20392 *	6777	7371	8387	8948 *
Population Density (person/km2)	2897	3069	3238	5070	1617	1712	1819	2203	679	701	727	728

Note: * Recorded in 2005
Source: BPS Sleman, 1997: 2000; 2003; 2006

From Table 4.1, it is noted that Depok has the highest number of population even though the annual population growth is relatively similar among the three districts. In 2006, there was a staggered increase of population growth in Depok District and a little in Ngaglik District which was due to the earthquake occurrence in Bantul Regency that brought many foreigners and volunteers to stay in nearest safe area. Meanwhile in Pakem District, the population growth has been relatively low and stable.

According to the statistical records, quantity of students contributes a great deal to the number of population especially in Depok District and Ngaglik District. In Kaliurang Street Corridor, the composition of students is dominated by students from Gadjah Mada University (UGM) and Indonesian Islamic University (UII). The number of UII and UGM students has been steadily escalating from 1997 to 2005 (see Table 4.2).

Table 4.2 The Number of Students of All Degree in UGM and UII, 1997 – 2005

University	Number of Students (person)			
	1997	2000	2003	2005
UGM	3000	5000	6077	25323
UII	1000	2000	3000	12256

Source: Academic Affair Division of UGM and UII, 2007

4.2 Urban Morphology and the Spatial Characteristics

The great advantage of remote sensing technology and GIS application for urban mapping has been put into practice earlier in Yogyakarta City by a few scholars. In 1999, Gunawan and Suryantoro observed the physical urban expansion from 1959 to 1996 using Landsat Thematic Map (TM) and SPOT images supported by other thematic data such as slope map, geomorphology map, geology map, hydrology map, and water quality. The result showed that there was a rapid expansion to the north and east area indicated by blue color in the SPOT images scale 1:80,000 (see Figure 4.1)

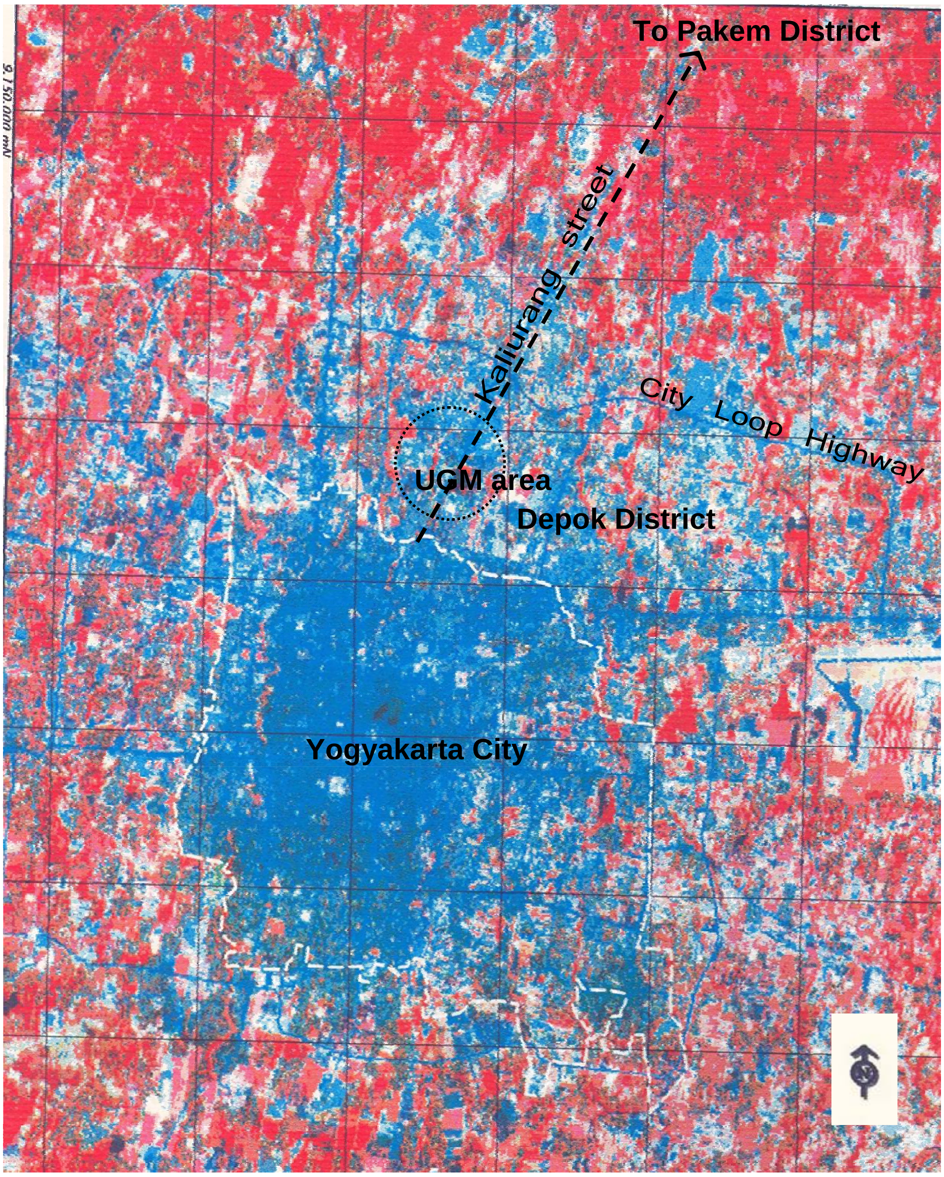
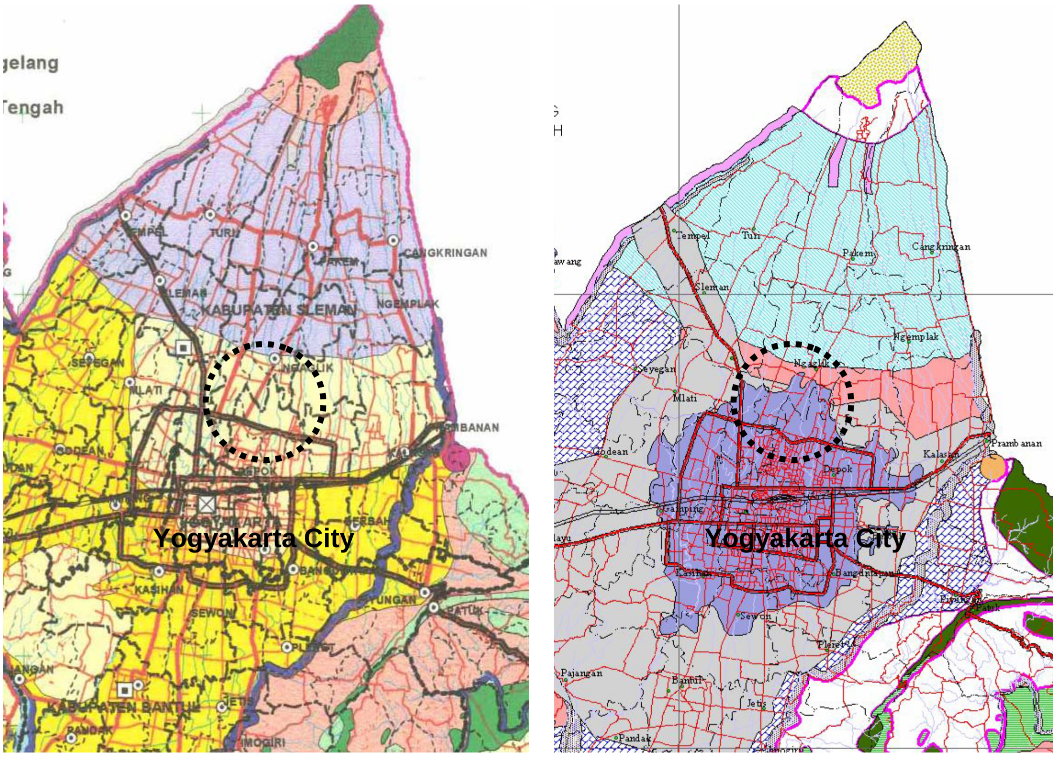


Figure 4.1 The Land Use Map of Yogyakarta Urban Area interpreted from SPOT XS Images 1996

Figure 4.1 shows that land use development in Depok District is fostering in the proximity to UGM and growing to the east part following the development of city loop highway. However, in 1990, Indonesian Islamic University (UII) moved its campus from the city to Ngaglik close to the border of Pakem District which tends to change the direction of urbanization to the northern fringe. The two universities have been famous as the campus for upper-middle class society. Thus, the development of facilities and service for student has been expanded from basic needs to the high-class lifestyle environment in the proximity to the campus, which has fostered and intensified more commercial activities along Kaliurang Street Corridor toward Ngaglik and Pakem District. Moreover, this occurrence is verified with the Land Use Map of Yogyakarta Province 1999/2000 and 2005 (see Figure 4.2).



(a) 1999/2000

(b) 2005

Figure 4.2 The Land Use Map of Sleman Regency in 1999/2000 and in 2005

From Figure 4.2, it can be perceived that the indigo blue color in Land Use Map 2005 (Fig. 4.2b) represents the agglomeration of Yogyakarta Urban Area and the circled area shows the direction of spatial growth from 1999 to 2005 toward the northern fringe.

According to the report of BAPPEDA Sleman (2006), the physical expansion of the city to the northern fringe has shaped the spatial characteristics of Depok, Ngaglik and Pakem District, which is reflected in the Land Use Zoning Map 2005 of each district which is consecutively described in the following sections.

4.2.1 Depok District

Depok District is one of Sleman Regency's jurisdiction area that shares administrative border with Yogyakarta City in the north part, thus it has been developed earlier due to its proximity to the city, as it is studied by Gunawan and Suryantoro (1999). Therefore, the composition of its land use type in 2005 has illustrated a robust urban characteristic such as less presence of agricultural lands and the higher density of built up area, as shown in Figure in 4.3. More than 80% of the area has been built into settlements, educational areas, commercial and service areas. Due to the presence of UGM, the commercial and service areas are spread out not only along the arterial road but also along the local road in the neighborhood. The business is mostly related to education as well as pleasure that greatly facilitate the scholar's liveliness such as photocopy shops, stationeries as well as fancy restaurant, bakery and café, fancy boutique and big tenant supermarkets.

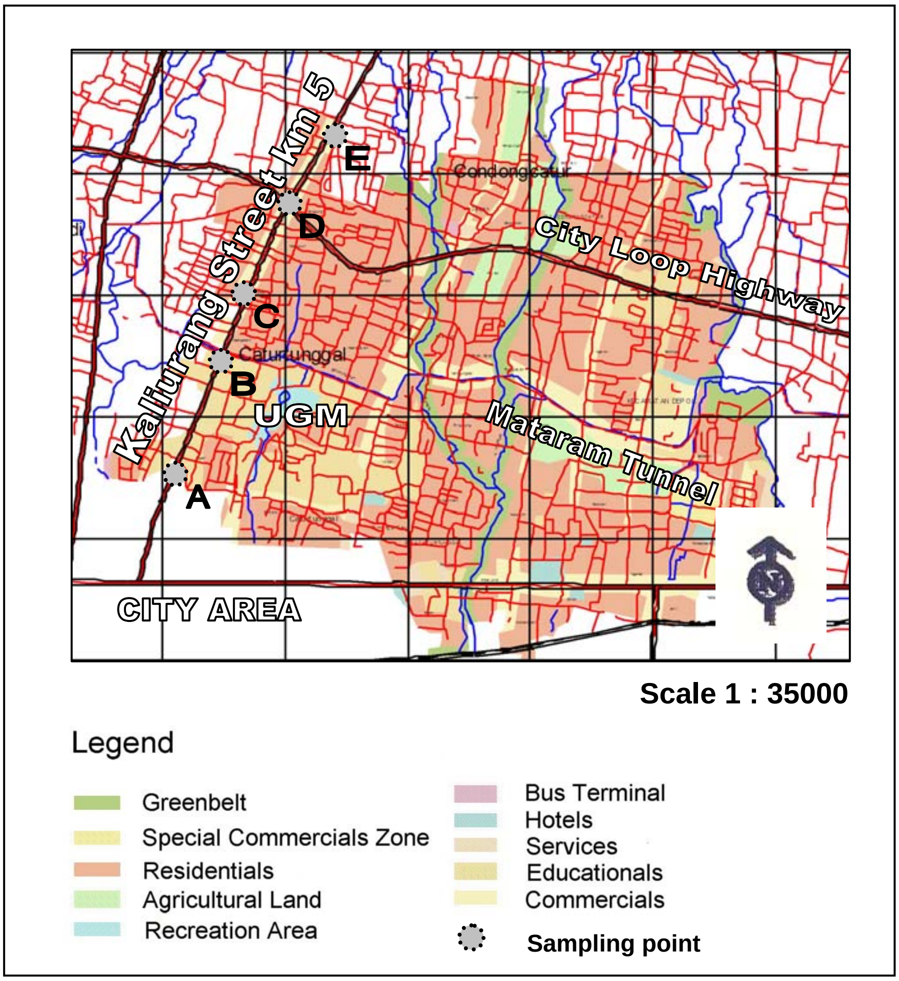


Figure 4.3 Land Use Zoning of Depok Municipality
Source: BPPD of Sleman Municipality, 2005

As the number of student is increasing, the municipality has established a Special Commercial Zone to accommodate the tourism and education-related businesses such as culinary corners, boutiques and cafés. The zone has been developed along the Mataram Tunnel, remnant from the colonial era.

4.2.2 Ngaglik District

The area of Ngaglik District is located within 7 to 14 km from the city. The development in Ngaglik District has started when the UII campus has been relocated to Kaliurang Street km 14 in 1990. UII has been famous for its upper-middle class scholars, thus it has also encouraged more urban activities on the area. In 1999, there was a development of first exclusive upper-middle housing in Yogyakarta Province, the "Merapi View Residents", in in Kaliurang Street km 9 on the west part of point J intersection (BAPPEDA Sleman, 2006). The accomplishment of Merapi View Residents has contributed a great deal to land use changes in Ngaglik District. In 2005, commercial area is proliferating not only alongside Kaliurang Street but also alongside the collector road to Merapi View Residents, as shown in Figure 4.4. In order to accommodate the urban lifestyle of the upper-middle class society, the business established in this area is particularly related to amusement and house materials instead of education, for example: beddings, furnitures, game centre, swimming pool and food corners.

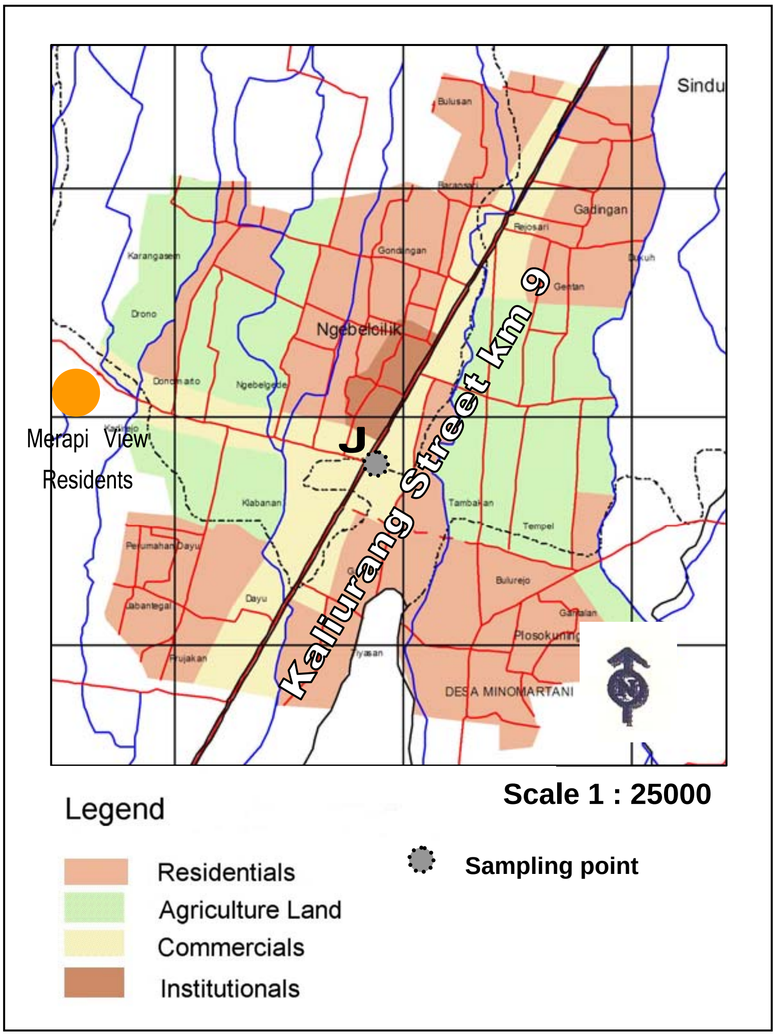


Figure 4.4 Land Use Zoning of Ngaglik Municipality
Source: BPPD of Sleman Municipality, 2005

The presence of Merapi View Residents has also created more people's mobility thus intensifying the activity on the intersection, so that the intersection has been famous as "Merapi View T-junction" (point J). However, there are still many native inhabitants which depend on agricultural activity for living. From Figure 4.4, it is shown that the presence of agricultural land in Ngaglik District is still fairly high, thus it illustrated a rural-urban characteristic.

4.2.3 Pakem District

The area of Pakem District is located 16 to 21 km from Yogyakarta City. Most of the area is located in the slope of Mount Merapi, thus it has the major benefit of the mountain's nature environment such as good quality of air, water and soil. In practice, agricultural activity is the major livelihoods for the native inhabitants, thus the area is still has a solid rural characteristic.

The urbanization in Pakem District has been influenced by the presence of the provincial Hospital for Mental Illness in the municipality area since 1990s (see Figure 4.5). However, due to the remoteness to the city, the growth of development is considerably low, thus in 2005 the municipality of area is still dominated by agricultural land.

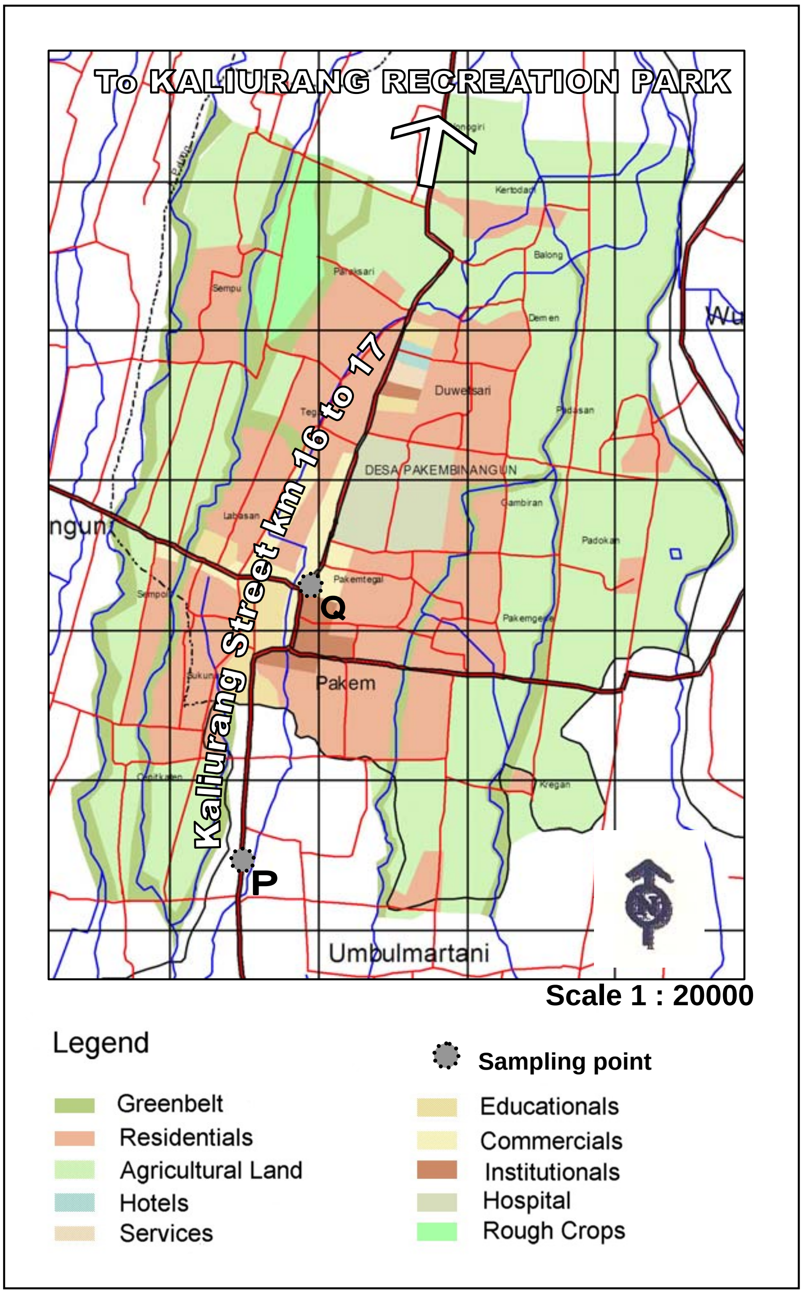


Figure 4.5 Land Use Zoning of Pakem Municipality
Source: BPPD of Sleman Municipality, 2005

Because of its proximity to Mount Merapi, Pakem District has the major benefit of its natural resources. According to BAPPEDA Sleman, 2006, the natural resources have contributed a great deal to the regional income of Sleman Regency. Aside of agricultural products, the presence of Kaliurang Recreation Natural Park in the slope of Mount Merapi is also fostering tourism industry which enhance the socio-economic life of the native inhabitants.

Moreover, because of the water quality, many rivers in Pakem District are occupied as the main water resource for Drinking Water Department of Yogyakarta Urban Area (including

Sleman Regency, Yogyakarta City, Bantul Regency). Therefore, water bodies become the biggest environmental concern and consideration in planning. In 2005, the municipality has planned a development of greenbelt along the riverbank to preserve the quality of water (BAPPEDA Sleman, 2006).

4.3 Land Use Changes and the Leap Frog Development

According to the reviewed theory in the realm of urban morphology, the physical growth is better observed from land use changes from rural use to urban use. The rural land use is characterized by the dominant existence of agricultural lands, whereas the urban land use is represented by the dominant existence of built up area and pavements. In Sleman Regency, the land use type is classified as wetland, dry land, house compounds and others. Wetland refers to rice fields whereas dry land refers to yielded-crop land, thus both are categorized as agricultural lands. Meanwhile, the house compounds and others are categorized as non-agricultural lands which are usually related to urban activity including new housings, offices, shops, roadways and paved area.

Based on the statistical records, BAPPEDA (2006) reported there was massive land use changes from the agricultural use to non-agricultural use from 1988 to 2002 (see Table 4.3).

Table 4.3 The Growth of Land Use Change of Depok, Ngaglik and Pakem District, 1988 – 2002

LAND USE CHANGE	Depok			Ngaglik			Pakem		
	1988	2002	Change per year	1988	2002	Change per year	1988	2002	Change per year
	Area (ha)								
Wetland	653	585.8	-4.8014	2014	1905	-7.7807	1816	1787	-2.1093
Dry Land	421	388.2	-2.3464	216	199	-1.2421	364	356	-0.5543
House Compounds	1340	1433	6.6071	1215	1339	8.8743	1021	1054	2.3771
Others	1141	1149	0.5414	407	410	0.1486	1183	1187	0.2864

Source: BAPPEDA Sleman, 2006

From Table 4.3, the land use changes in three districts can be observed statistically. In Depok District, the annual loss of wetland and dry land are consecutively –4.8014 ha and –2.3464 ha, whereas the annual raise of house compounds is 6.6071 ha. In Ngaglik District, the annual loss of wetland and dry land are consecutively –7.7807 ha and –1.2421 ha, whereas the annual raise of house compounds is 8.8743 ha. Meanwhile, in Pakem District the annual loss of wetland and dry land are consecutively –2.1093 ha and –0.5543 ha, whereas the annual raise of house compounds is 2.3771 ha. It is shown that from 1988 to 2002, there is an immense loss of agricultural land along with the enormous raise to house compounds in Depok District and Ngaglik District, whereas the changes growth in Pakem District is fairly lower down than the other two.

The type “others” in the land use classification represented paved roads and transportation infrastructures. On the contrary to the house compounds growth, the change in the quantity of road from 1988 to 2002 in three districts is considerably low. The annual raise of land use development for road infrastructures in Depok, Ngaglik and Pakem from 1988 to 2002 is respectively 0.5414 ha, 0.1486 ha and 0.2864 ha.

This was verified by the statistical record of land use allocation in Sleman Municipality from 2000 to 2006, as shown in Figure 4.6.

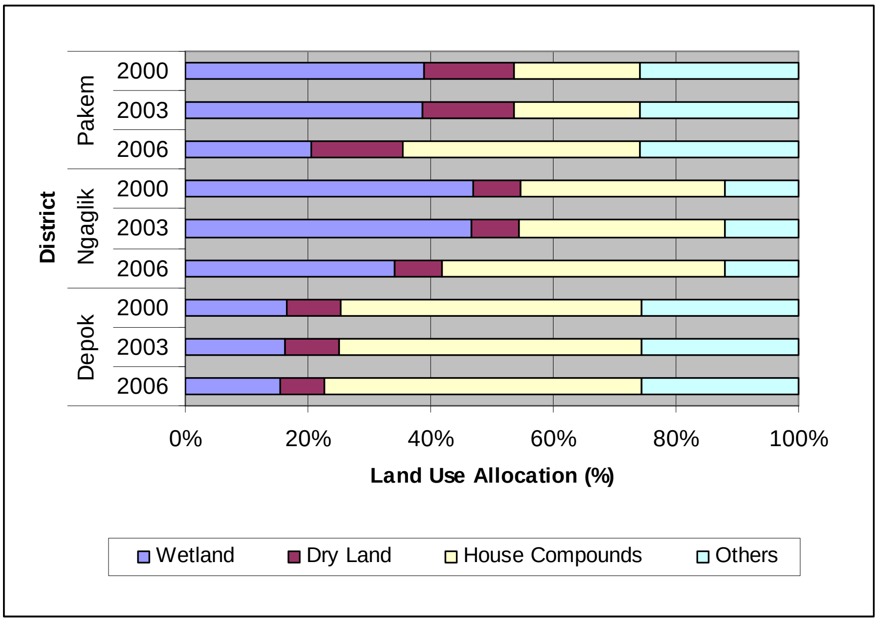


Figure 4.6 The Land Use Allocation of Depok, Ngaglik and Pakem District, 2000 – 2006
Source: BPS Sleman, 2000; 2003; 2006

From Figure 4.6, it can be observed that in Pakem District from 2000 to 2003, 50% of land use was allocated for agricultural lands and another 50% was allocated for built area. However, in 2006, there was considerable loss of wetlands, thus the agricultural lands were decreased into 35%, whereas concurrently, the built up area has reached 75% of the land use allocation. Similar occurrence happened in Ngaglik District. From 2000 to 2003, the land use share between agricultural lands and built up area in Ngaglik was still fairly equal. However, in 2006, the wetlands were fairly decreased, thus the percentage of agricultural area has declined into 42%, whereas concurrently, the figure of built up area has been escalated into 68%. Meanwhile in Depok District, the land use allocation from 2000 to 2006 has fairly unchanged, 25% for agricultural lands and 75% for built up area. It can be perceived that the land use changes from agricultural lands to built up area have vividly appeared in Ngaglik District and Pakem District showing that the urbanization process is going toward the northern fringe of Yogyakarta Urban Area.

From the statistical figure of land use allocation, it can be perceived that as the agricultural lands decrease, the built up area is increasing without any consideration for green space in the land use allocation. Nevertheless, according to the Environmental Impact Control Agency of Sleman Regency, there has been a forest and land rehabilitation program (GNRHL/GERHAN) from 2003 to 2007 to increase the green space/vegetation in Sleman Regency. The vegetation is allocated for the water quality preservation along the riverbanks. Until 2007, there has been an increase of vegetation as much as 2439 ha from the program (KPDL, 2006).

4.3.1 Leap Frog Development

Because of the difference of spatial characters and potential resources in each district, the change of land use along Kaliurang Street Corridor is going in the leap frog type. In 2007, land use mapping from Quickbird Image 2005 and DigitalGlobe Image 2007 of 15 sampling points along the street has been done and the leap frog phenomenon can be observed promptly in the building density figure of the sampling points, as shown in Figure 4.7.

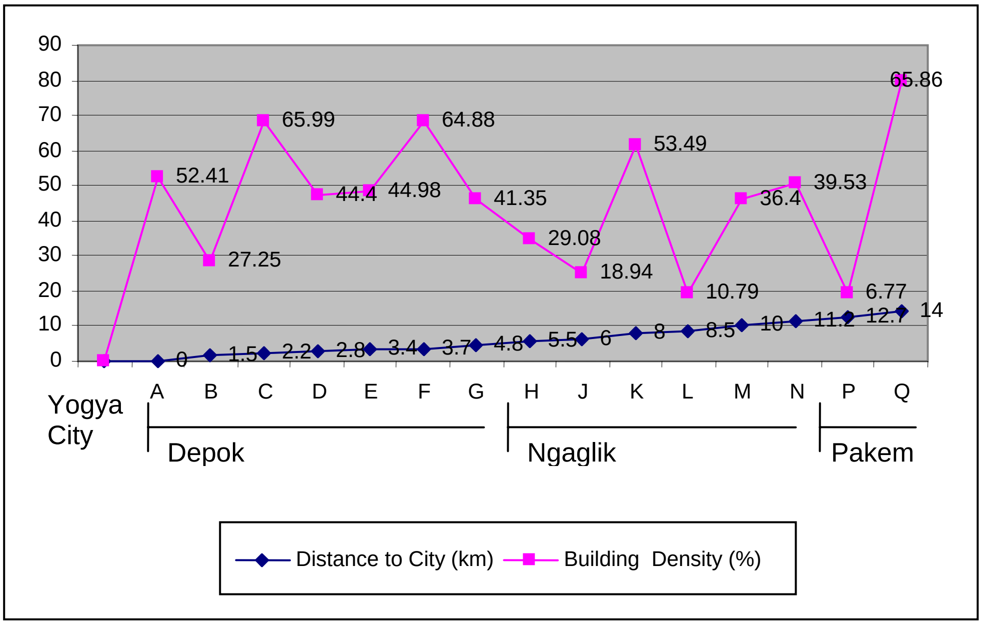


Figure 4.7 Statistical Figure of Building Density in 15 Spots along Kaliurang Street Corridor

According to Nelson, 1955 and Amiruddin et al., 1970 in Yunus, 2005, urbanized area is characterized by high building density. From Figure 4.7, it can be observed that the building density is fluctuating as the distance to the city increases. The extreme highest points are A, C, F, K and Q, whereas the extreme lowest points are H, J, L and P. Thus, it can be inferred that A, C, F, K and Q has already been urbanized area, while H, J, L and P are still growing from rural to urban setting. The complete result of statistical figure is listed in Appendix 2. Meanwhile, the condition of land use changes is accurately illustrated in Quickbird Image 2005 with ground truth observation in 2007 (see Figure 4.8).

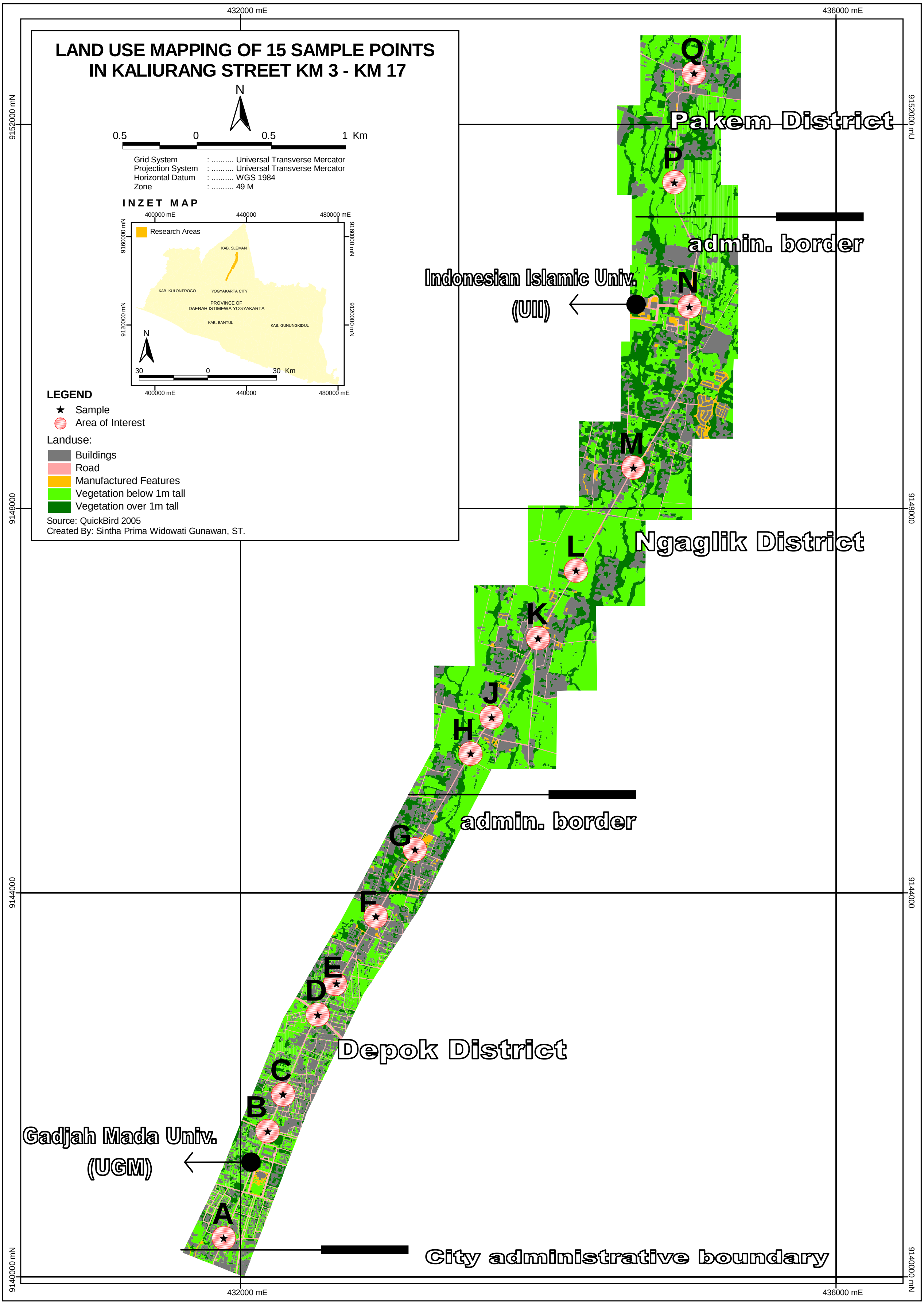


Figure 4.8 Existing Land Use Map of Kaliurang Street Corridor from km 3 to km 17 depicted from Quickbird Image 2005 and DigitalGlobe Image 2007

Furthermore, the following discussion of land use changes is segregated into land use changes in urban setting and in rural-urban setting, which refer to the result of land use mapping of each point which is consecutively illustrated in Appendices 3 to 17. The appendices provide meticulous information on the existing condition of land use in each point in 2005 thus facilitates the discussion about the changes based on ground truth observation in 2007.

4.3.2 Land Use Changes in Urban Setting

The identification of land use changes in urbanized area is not an easy task, because most of the area has been covered with building feature. Thus, the changes are observed from physical appearance or the function of the building. According to land use mapping from Quickbird Image 2005, the urbanized area has been found concentrating in the vicinity of a marketplace such as supermarket (Point A (52.41%) and C (65.99%)) as well as traditional fresh market (Point F (64.88%), K (53.49%) and Q (65.86%)).

Point A and C are located in Depok District, very close to the city administrative boundary. However, point C (Gading Mas Minimarket) has higher density than A (Mirota Kampus Supermarket) even though A is located 0.0 km from Yogyakarta City. It is because point C is surrounded by residential area whereas A is surrounded by institutional buildings such as senior high schools and the UGM Main Library (see Figure 4.9).

Figure 4.9 Point A – Mirota Kampus Supermarket Intersection

From Figure 4.9 it can be observed that there is still some open space existing in the institutional buildings such as for parking, gathering and greeneries. Meanwhile, in point C, from the field observation it is found that the land is fully in use with building features. Along the road, the buildings are functioned as small-medium scaled business places such as photocopy shops, drugstore, computer and electronic shop, boutique, bedding and mattress shops and restaurants, whereas greeneries can hardly be found (see Figure 4.10).

Figure 4.10 Small-Medium Scale Businesses in Point C (Gading Mas Minimarket)

Based on ground truth observation in 2007, the change in point A is identified in the southern side of Mirota Kampus Supermarket (see Appendix 3i). There is a new fancy restaurant founded replacing an exclusive residence on that site (see Figure 4.11a). Meanwhile, in point C, the change is identified in front of Gading Mas Minimarket (see Appendix 5i). There is a new three stories building still under construction (see Figure 4.11b).

(a) (b)

Figure 4.11 The Changes in Point A and Point C

Based on the informal interview to the neighbors, it is known that it used to be a one storey motorcycle mechanic shop and will be in use for house fabrics shop. It can be observed in Figure 5.5b that since there is limited vacant land, the change is growing vertically. Thus, it can be inferred that there is change in function as well as in the form.

Overall, the building density of sampling points in Depok District is fairly high (from 41.35 % to 65.99%). However, point B has low figure because one forth of the area is a forest laboratory of UGM (see Figure 4.12; Appendix 4i).

Figure 4.12 The Forest Laboratory of UGM

Meanwhile in the vicinity of the fresh markets, the changes are more stagnant. Those fresh markets are established before the city. However, the characteristics of the surroundings are gradually changing such as the type of business and the characteristics of the residents.

In point F (in front of Colombo Market), the changes are identified in the function of the building such as the change from small groceries shops to small internet café or electronic shop (see Figure 4.13a; Appendix 6). In point K (in front of Gentan Market), the changes are identified from the form of the building. Based on the informal interview with the owner of the shops, it is found that most of them are native residences that earlier used the house to establish a small business. As the business raise in the first floor, they build the house in the second floor instead of building a house in another land (see Figure 4.13b; Appendix 10)

(a) (b)

Figure 4.13 Business Place in Colombo Market and in Gentan Market

In point Q (in front of Pakem Market), the most noticeable changes are the proliferating telecommunication shop along the road. It is indicating that there has been an influence of urban lifestyle in the area, although the shops are considerably undersized (see Figure 4.14).

Figure 4.14 Telecommunication Shops in Pakem Market

4.3.3 Land Use Changes in Rural-Urban Setting

The identification of land use changes in the rural-urban area is moderately less complicated than in the urbanized one. The changes can be identified from the loss of agricultural lands into the building features. The rural-urban setting is indicated by lower figure of building density and higher percentage of agricultural lands as shown in point H (in front of Social Agency Book Store), J (T-junction of Merapi View), L (in front of WS Minimarket) and P (in front of Mirota Batik). All of the rural-urban area is located at Ngaglik and Pakem District.

The land use maps of point H, J, L and P illustrate that there are sporadic growth of building features within the agricultural lands (see Apendices 8, 9, 11 and 14). Based on ground truth observation in 2007, the changes in land use have been found in point H, J and L, whereas the land use development in point P have been fairly dormant.

In point H, the changes along the road are noticeable. From the map image, it is identified that in 2005 there were only few building features including Social Agency Bookstore. It was also identified there were still some green lands along Kaliurang Street. However, based on the ground checking in 2007, the green lands along the road are all changed into business places such as small restaurants, building materials shop and laundry shops (see Figure 4.15). Those kinds of shop are shops which occupy small amount of land but generate excessive travel activity.

Figure 4.15 The New Building Features in front of Social Agency Book Store

In point J, the changes are quite extensive. Based on the ground checking of the map, the green lands in the south-east are unchanged (see Figure 4.16a), however, the one in the south-west of the intersection has been developed into new upper-middle class housings “Pesona Merapi”, and the main gate is heading to Kaliurang Street, about 15m to the intersection (see Figure 4.16b). However, based on the ground check in 2007, there is no land use change into commercial spot since 2005.

(a) (b)

Figure 4.16 The Main Gate of Upper-Middle Class Housing in Kaliurang Street km 9

As it is described in the Land Use Zoning Map of Ngaglik Municipality, the existing commercial spots are more related to amusement. Thus, it has intensified the travel activity and raised some conflicts particularly on the intersection area. In order to deal with that, the Provincial Transportation Bureau has done a capacity survey on the intersection. As a result, in 2005 the 3 legged-intersection has been enhanced with traffic light signal (see

Figure 4.17). According to the officials from the Provincial Transport Bureau and the traffic police men in charge on the spot, the conflicts tend to decrease since the traffic signal has been operated.

Figure 4.17 The Traffic Light Signal in the T-junction of Merapi View

In point L, the change is identified next to WS Minimarket. In the map image, there was a green lands next to the minimarket. However, based on the current ground truth observation, there is a new-built shop next to the minimarket called “BarkaS” which sells new and second hand materials (see Figure 4.18). It can be inferred that this shop was founded after 2005.

Figure 4.18 Newly-built Shop “BarkaS” next to WS Minimarket

Meanwhile, in point P, the change growth from agricultural lands to urban land use is fairly running at a low level. Based on the informal interview, it is known that Mirota Batik was founded in 1997, followed by WS Minimarket in 1999 and Social Agency Bookstore in 2004. Mirota Batik is the most famous handicrafts shop in Yogyakarta City which is owned by the big local tenant, “Mirota” business enterprise. There are only two shops of Mirota Batik in Yogyakarta Province. One is located at the city core, 0.0 km of Yogyakarta City and the branch was founded in 1997 in Pakem District, 12.7 km from the city.

In 2003, there is one famous restaurant with traditional setting and full of trees founded next to Mirota Batik Handicraft Shop (see Figure 4.19). In the Quickbird Image 2005, the restaurant building feature was not captured because it is covered with the vegetation’s crown (see Appendix P). Thus, it cannot be identified in the land use mapping. However, based on the ground check of the land use mapping, there is no significant change from 2005 to 2007 in point P.

Figure 4.19 Tourism Facilities in Kaliurang Street km 16

In general, the land use development in rural-urban area is fairly slower than others. From the land use map illustrations, it can be observed that the lands are still dominated by agricultural lands such as rice fields and croplands.

However, as tourism industry raise, many of green lands along the road are changed into botanic farm shops such as in front of WS Minimarket and in front of Mirota Batik (see Figure 4.20). This trend happens particularly in the upper part of Kaliurang Street from km 10 to the direction of Kaliurang Recreation Natural Park.

Along with the botanic farm shops, the restaurant businesses have also been fostering, especially sea food restaurant. This is supported by the beautiful natural scenery on the spot. The seafood restaurant is originally using fresh water fish nurtured in the river from Merapi Mountain.

One of the famous “sea food restaurants” is Toraja Sea Food Restaurant in point M. The restaurant is surrounded by agricultural lands (see Figure 4.21; Appendix 12i, 12ii and 12iii). Thus, the figure of building density in point M is slightly elevated although it is located in the rural-urban area. However, the land use changes in this point are fairly dormant.

Figure 4.20 The Botanic Farm Shops

Figure 4.21 The Surroundings of Toraja Seafood Restaurant

The other elevated building density figure in the rural-urban setting is point N (in front of UII campus). The campus itself is located approximately 250m from Kaliurang Street (see Appendix 13i). The presence of UII campus has fostered the land development in the area. There are many small-medium businesses proliferating in the surroundings of the campus to facilitate the students such as photocopy shops, telecommunication shops and food shops (see Figure 4.22).

Figure 4.22 The Commercial Area in front of UII Campus

The growth of land use changes in this area is quite vivid since the campus is famous for its upper-middle class students that have extraordinary lifestyle. The changes in 2007 can be observed in the vicinity of the campus such as the development of exclusive salon and spa and the fancy traditional restaurant (see Figure 4.23). It indicates that the presence of UII campus can be one of the development magnets in Kaliurang Street Corridor.

Figure 4.23 The Extraordinary Student Facility in front of UII Campus

4.3.4 The Informal Sectors

Based on the field observation, it is recognized that in both urban and rural-urban setting, there is one element that cannot be separated from development. That element is the informal sectors. The presence of informal sectors is bringing extra benefits to the liveliness in Yogyakarta Urban Area. It offers such a good opportunity for livelihoods as well as it is greatly facilitates the people’s contentment. However, in the realm of urban planning and management, the presence of the informal sectors, even the smallest feature, may raise some urban management issues. These kinds of business have created more travel generation without any capacity to accommodate the customers, which mostly a motorized vehicle user. Thus, many of them are using the roadway as a parking place and decrease the capacity of the road, leading to the potential of traffic congestion. For example, in point A, there are snacks and beverages booth and food stall close to the intersection (see Figure 4.24). The vehicles are parked in the roadway, which have the potential to disrupt the traffic flow in the intersection when the green light is on.

Figure 4.24 Informal Sectors in Point A

In point C, the presence of snack booths across the supermarket has been also force the people to stop the vehicles on the roadway (see Figure 4.25). Moreover, the supermarket and the business spots on the area do not provide sufficient space for parking. Thus, the roadside in both lanes is occupied for parking, leading to the decreasing of road capacity to accommodate the excessive traffic volume.

Figure 4.25 Snacks Booths across Gading Mas Supermarket in Point C

The similar phenomenon happened almost along Kaliurang Street Corridor with various kinds of good and items to sell such as telecommunication booth which sells SIM card and credits reload for mobile phone in point N (see Figure 4.26a) as well as newspaper/magazine booth and vehicle plate maker in point Q (see Figure 4.26b and 4.26c). Those kinds of business are facilitating a great deal to the inhabitants' liveliness.

(a) (b) (c)

Figure 4.26 Various Kinds of Informal Sectors Business

In transportation system management, the presence of informal sectors is perceived as roadside features that disrupt the traffic activity on the street since they usually put up the business in the road shoulder with insufficient space for parking, thus the roadways will be in use that will decrease the road capacity for accommodating the excessive traffic flow.

4.4 Driving Forces of Land Use Changes

From the discussion above, it is shown that from 1988 to 2002, Ngaglik District has the biggest lost of agricultural land and the highest growth of house compounds. On the other hand, it has the least development of road and transportation infrastructures. Study of Yunus (2002) found that people from further remote area and people from the city are attracted to move to the northern fringe. The determinant factors of people movement from the city to the northern fringe are consecutively ranked as follows: (1) the availability of cheaper land; (2) the availability of land for future investment; (3) the availability of more spacious land. Meanwhile, the attracting forces of people movement from hinterland to the northern fringe are ranked as follows: (1) the proximity to the workplace; (2) the availability of land for future investment; (3) the proximity to the activity's facilities.

It is noted that the future land investment is posed on the second rank in both movements. From the economy perspective, whenever there is an investment, the land value will always be increasing. This phenomenon is influencing the commitment of the farmers to their agricultural lands and activities in the urban fringe areas (Yunus, 2003). They tend to sell rather than commit to do cultivation.

In 2004, Rachmawati et al. found that the presence of two most prestigious universities has been the driving force to the rapid development in Kaliurang street corridor. Those universities are Gadjah Mada University (UGM) and Indonesian Islamic University (UII). UGM campus area was founded in 1949 located in Kaliurang Street km 3 – 4, whereas the location of UII campus was moved out of the city area to Kaliurang Street km 14 in 1990.

Following to the identification of the land use changes in Kaliurang Street Corridor from km 3 to km 17 in 2007, a questionnaire to seek the driving forces of the changes has been distributed to 15 officials who deal with urban and land use planning (see Appendix 18). The questions are developed from field observation as well as previous studies and theory on urban spatial growth. The result of the questionnaire is presented in Figure 4.27.

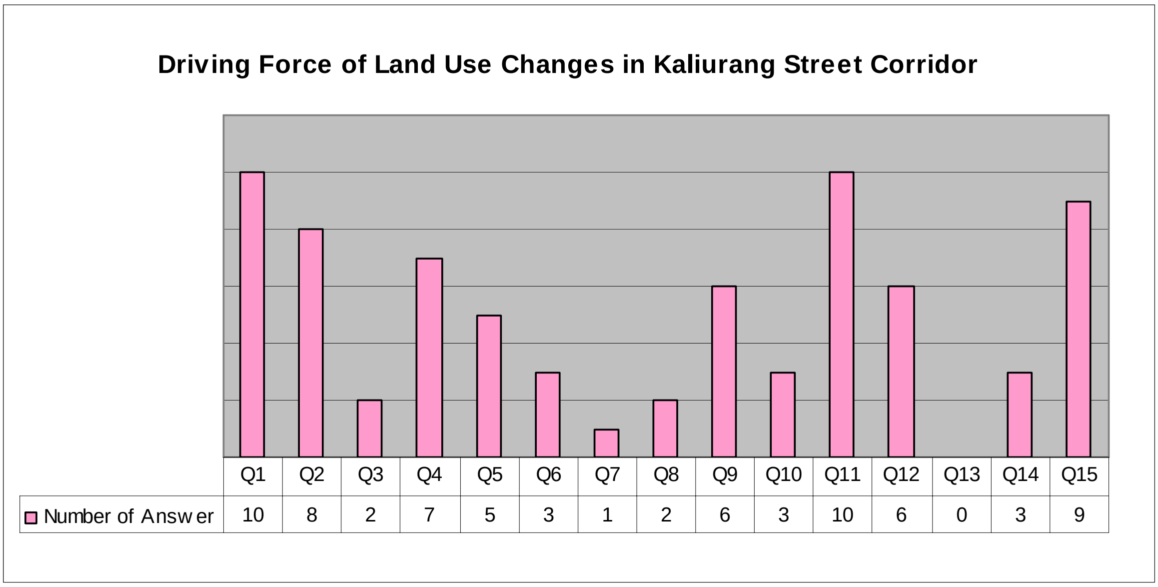


Figure 4.27 The Driving Force of Land Use Changes in Kaliurang Street Corridor

From Figure 4.27, it can be observed that the leading five answers are:
1. The enhancement of transportation link to Kaliurang direction (Q1)
2. The remarkable level of accessibility to the UGM campus (Q11)
3. The proliferating of new economic growth centers along Kaliurang Street Corridor (Q15)
4. The presence of UII campus in Kaliurang Street km 14 (Q2)
5. The presence of Kaliurang Recreation Nature Park (Q4)

According to the deputy chief officer of Traffic Division on the Provincial Transportation Bureau, the enhancement of transportation link is the upgrading level of the asphalt layers which has been done in Kaliurang Street from km 8 to km 14 in 2005. This fine and smooth lining asphalt road has attracted people to move to northern fringe, particularly for the people who used to study in Gadjah Mada University, build a new family in Yogyakarta City, and continue to work in the university.

As there are settlements, there will be market for basic needs. However, since the development is leap-frogging to the northern suburb, the economic activities are also proliferating sporadically in the rural-urban area. Thus, it has created many growth centers that attract more businesses to the northern fringe such as in point H and L. The proliferating businesses are mostly related to education and tourism because of the presence of UII campus in km 14 and Kaliurang Recreation Nature Park in the slope of Mount Merapi.

Meanwhile, mostly people put the first rank of driving force on:
1. The proliferating of new economic growth centers along Kaliurang Street Corridor (33.6%)
2. The presence of UII campus in Kaliurang Street km 14 (20%)

3. The remarkable level of accessibility to the UGM campus (20%)
4. The enhancement of transportation link to Kaliurang direction (6.6%)
5. The trend of development growth in Yogya City is toward the northern fringe (6.6%)
6. The availability of various urban facilities along the road (6.6%)
7. The presence of Kaliurang Recreation Nature Park (6.6%)

4.5 Concluding Remarks

The physical growth of Yogytakarta Urban Area to the northern fringe has been recognized in the statistical figure of land use changes growth in Depok, Ngaglik and Pakem District from 1988 to 2002. The figure shows there are enormous loss of agricultural lands which changed into built up area. Moreover, the land use changes to the northern fringe have been verified in 1999 by the scholars using land use map interpreted from SPOT XS Image 1996. The Statistical Agency of Sleman Municpality has recorded that the loss of agricultural lands is still continuing, particularly in Ngaglik and Pakem District. The urban expansion to the northern fringe has established a specific spatial characteristic of the three districts. Quite the reverse, the spatial characteristics has also induced the nature of land use changes on the area. Because of the remoteness to Yogyakarta City and the different potential resources, the physical expansion has been growing in leap frog type. This phenomenon has been observed in 2007 using land use map that is interpreted from Quickbird Image 2005 and DigitalGlobe Image 2007. The leap frog phenomenon is promptly observable in the figure of building density in 15 sampling location along Kaliurang Street Corridor which is connecting Depok, Ngaglik and Pakem District. The figure of building density can be obtained from the land use map using GIS application. The result shows that the figure of building density is fluctuating in parallel with the raise of distance to the city. This means that the land development is jumping from one spot to another based on its potential influencing forces, which has created more travel generation thus create more emission to the ambient air. Based on the questionnaire that distributed in 2007 to the officials who deal with land use planning, transport management and environmental impact control, the land use changes to the northern fringe area are mostly driven by the presence of two prestigious universities, UGM and UII, the presence of Kaliurang Recreation Area as well as the enhancement of road quality in Kaliurang Street km 8 to km 14.

Chapter 5

Transportation and Ambient Lead Level

This chapter is addressing the second research objective, thus it provides discussion about transportation and lead pollution due to the enormous growth of motorized vehicle in the northern fringe of Yogyakarta Urban Area, particularly in three districts along Kaliurang Street Corridor, Depok District, Ngaglik District and Pakem District of Sleman Regency.

5.1 Transportation System

In transportation system, the road network consists of arterial roads, collector roads and local roads, which has been fairly distributed all over the area of Sleman Regency, as shown in Figure 5.1. The roads are constructed with fine and smooth asphalt layers, particularly the arterial roads and collector road. The local roads are fairly reinforced with concrete or cement layers. However, some roads in the rural area are still barely layered with soil and gravel.

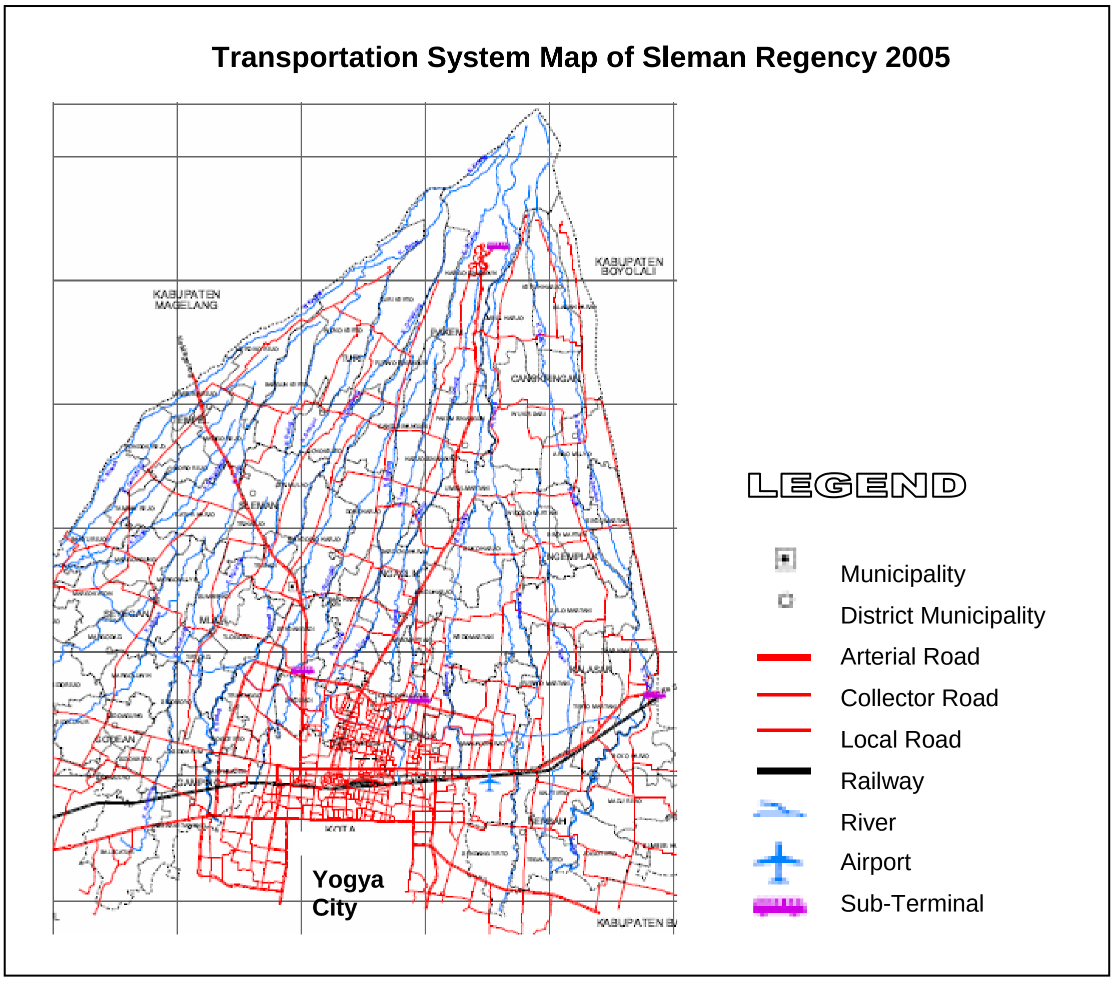


Figure 5.1 Transportation System Map of Sleman Regency, 2005
Source: BPPD Sleman, 2005

According to the BAPPEDA Sleman (2006), the uncontrolled growth of urbanization in the northern fringe has caused a considerably excessive traffic volume. Kaliurang Street is one of the road sections that have the potential to carry those traffic burdens from the urbanization process. This has become a serious concern of the municipality in regards to the road network development in Sleman Regency. However, due to the financial and technical planning process, the road network development cannot promptly follow the pace of urbanization.

5.2 Traffic Volume and Composition

According to ADB report, more than 95% of the traffic volume in Yogyakarta Urban Area is composed of motorized vehicle (Ammari, 2005). According to statistical records from 2001 to 2003, Sleman Regency has the highest growth of motorized vehicle number in Yogyakarta Urban Area (see Figure 5.2).

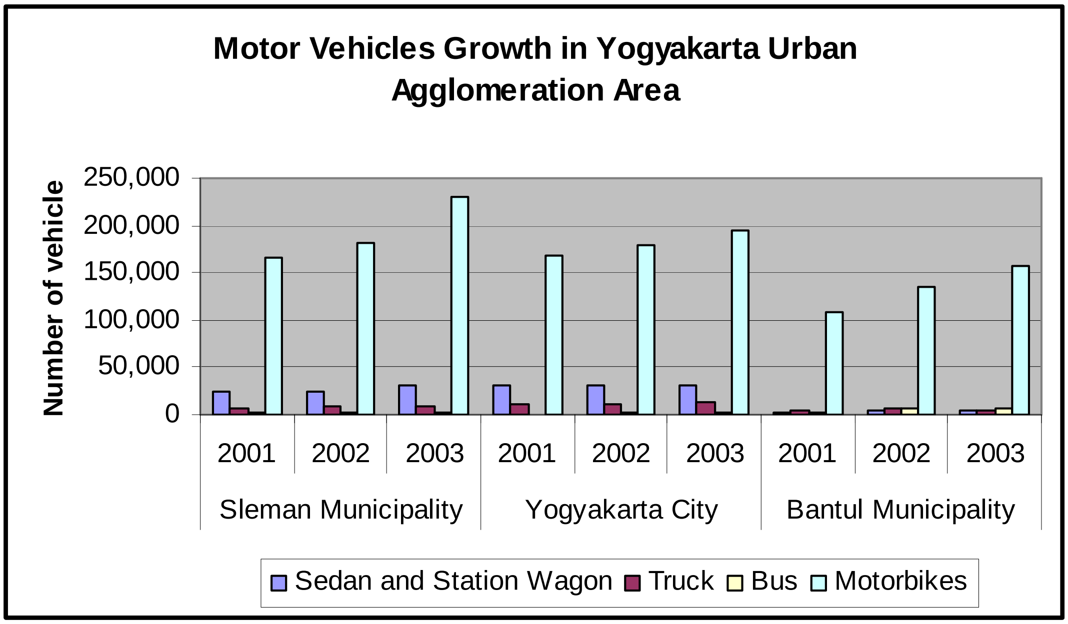


Figure 5.2 The Growth of Motorized Vehicle in Yogyakarta Urban Area, 2001-2003
Source: Developed from Municipality Statistic Data 2003 in Ammari, 2005

From Figure 5.2, it can be observed that from 2001 to 2003 motorbikes pose on the highest rank in all area and still steadily increase every year. Ammari (2005) noted that until 2005, the growth rate of motorbikes is 11.9% per annum, higher than of cars, 6.9% per annum. Ammari (2005) observed that motorbikes are used by most people because it is affordable, economical, convenient, and low-cost in fuel and in maintenance. The price of motorbike is reasonably fit in comparison with the travel cost of using the public transport for the long run. Within a fairly short distance, motorbike is quite convenient for personal transport. In comparison to car, it occupies smaller space, uses up less fuel and needs less maintenance. Moreover, there are a lot of financial agencies which facilitate purchasing motorbike by cash or credit.

The statistical record from Sleman Municipality shows that numbers of motorized vehicle in Depok, Ngaglik and Pakem District are vigorously increasing from 1997 to 2005, as shown in Figure 5.3.

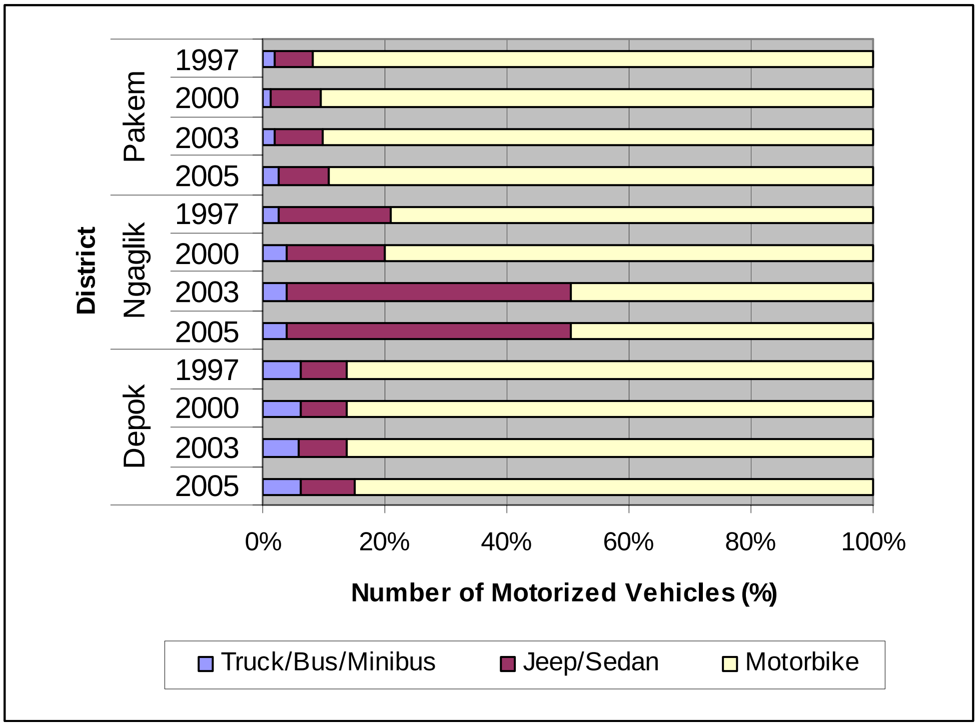


Figure 5.3 Percentage of Motorized Vehicles in Depok, Ngaglik and Pakem District, 1997–2005
Source: Sleman Municipal Statistic Agency (BPS Sleman), 1997; 2000; 2003; 2005

It can be perceived in Figure 5.3 that motorized vehicles in Yogyakarta are categorized into three groups which are truck/bus, jeep/sedan and motorbike. According to Provincial Transportation Bureau (2007), jeep/sedan and motorbike are private passenger vehicles, whereas truck/bus is usually in use for public transport or load vehicle. Thus, it can be inferred that almost 95% of the motorized vehicles in Yogyakarta Urban Area are privately owned.

The statistical figure in Figure 5.3 shows the vibrant growth of private vehicles in Depok and Pakem. The tremendous growth of number of private vehicle has been caused by the increase need to travel inadequacy of public transportation service and facilities (Ammari, 2005). However, in Ngaglik, there is vigorous raise in number of passenger cars, whereas the number of motorbikes is fairly going down. Ammari (2005) observed, this issue has been raised by the unregistered motorbikes owned by the in-migrant population in the area, which mostly the students of UII. According to the Academic Affair Division of UII, 75% of the students are coming from other provinces, and even other islands with high-class background. Thus, for those who are bringing motorbikes from their own place, the motorbikes are not registered in Sleman Municipality. Meanwhile, the number of passenger cars is vigorously increasing because those student who do not bring motorbike, are mostly buying car on the spot. Moreover, as a recently urbanized area, there are many newly-wed couples starting life in Ngaglik District to get affordable yet decent housings.

5.3 Fuel Characteristics

The ambient lead pollution issue has been raised because the leaded gasoline is still widely distributed in Yogyakarta City (ADB, 2006) and 95% of the vehicles are using this fuel (DISHUB, 2007). This has been verified with the statistical record of fuel trade in Sleman Regency in 2004 and 2005 (see Figure 5.4).

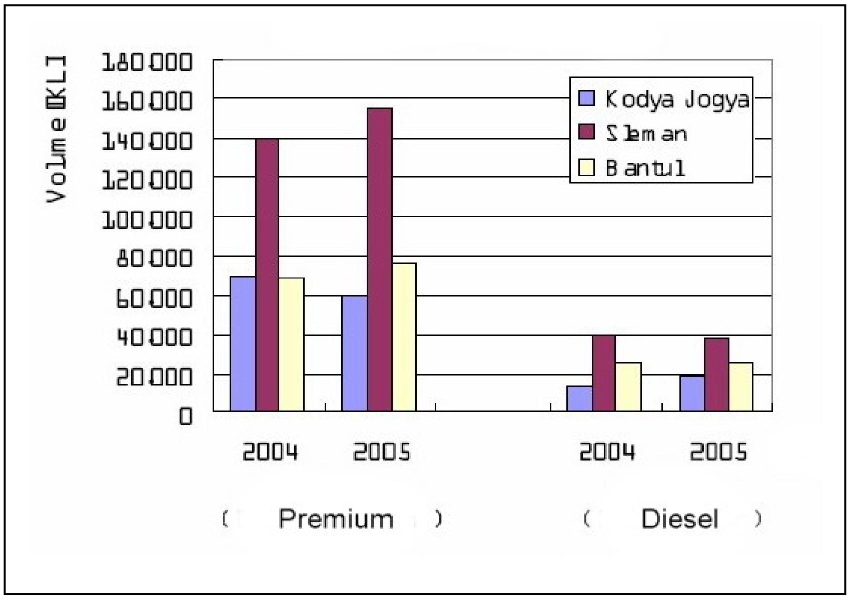


Figure 5.4 Fuel Trade in Yogyakarta Urban Area, 2004 – 2005

Source: Pertamina Upms IV 2006 in ADB 2006

Figure 5.4 shows that in Yogyakarta Urban Area, Sleman Regency is leading in annual fuel consumption for transport in 2004 and 2005 for both leaded gasoline (Premium) and diesel fuel (Diesel). Furthermore, the annual consumption of leaded gasoline in is extremely far leading among the three regions of Yogyakarta Urban Area in both years respectively 140,000 KL/year in 2004 and 155,000 KL/year in 2005. Although the data recorded in different year, the figure goes along with the enormous growth of motor vehicle in Sleman Regency, as shown earlier in Figure 5.2.

According to Dishub DIY (2007), Premium is consumed mostly by jeep/sedan and motorbikes, whereas Diesel fuel is consumed only by trucks and buses as public transportation. Thus, it is can be assumed that in practice, approximately 95% of motor vehicles in Sleman Regency use up the leaded gasoline.

5.4 Public Transportation

According to Regional Planning of Sleman Municipality, the public transport vehicles, which are in service to accommodate travel needs from the city to the northern fringe through Kaliurang Street Corridor, start from the administrative border of Yogyakarta City and ends up in one sub terminal in Kaliurang Recreation Nature Park (see Figure 5.5). However, the public transportation system in Sleman Regency, mostly in Kaliurang Street has not been adequately well-managed. The issues in public transportation system are listed as follows.

1. Lack of transport mode because there are only bus and mini van. They run along Kaliurang Street Corridor from the city to Kaliurang Recreation Park only.
2. Lack of number of vehicle (5% from the total number of motorized vehicle). However, most vehicles use diesel engine which has no lead additives on the fuel.
3. Time consuming in waiting for the vehicle, since there is only few number of vehicle.
4. Time consuming in the journey, since there is no fixed terminal to halt the vehicle, thus it can be stopped at anytime and anywhere which will prolong the journey time.
5. The vehicle condition is old. According to Dishub Sleman (2005) the age of most vehicles is around 10-20 years old. Thus, it raises the issue of safety and security for passengers.

Figure 5.5 Type of Public Transport Means in Kaliurang Street Corridor

Since the Better Air Quality workshop was held in Yogyakarta in 2006, the government has initiated the mass transit program to curb the congestion problem as well as to improve the ambient air quality in Yogyakarta City. The program started in early 2008, using air-conditioned bus with nice facility named “TransJogja” (see Figure 5.6).

Figure 5.6 Facility of TransJogja Bus in Mass Transit Program in Yogyakarta City

The TransJogja bus is operating in a better system. It stops only in the terminal booth located all over the city (see Figure 5.7). Moreover, passengers shall use a smart card instead of money to pay the fare. The smart card is available to purchase in the terminal booth.

Nevertheless, studies and research over the operation of TransJogja Mass Transit System are still ongoing for the sustainability of the program in the long run.

Figure 5.7 Terminal Booth of TransJogja Bus

5.5 Traffic Monitoring

Traffic monitoring has been regularly performed by Provincial Transportation Bureau (Dishub DIY) in order to bring up to date information of transportation system in Yogyakarta Urban Area. The monitoring has been conducted to analyze the traffic condition in a number of spots in busy roadways and intersections all over Yogyakarta Urban Area since 2005. According to Ammari (2005), traffic monitoring shall be conducted during the peak hours and off-peak hours. In Yogyakarta City which is considered as a medium city, the peak hours is in the morning from 6:30 to 8:30 and the off-peak hours is at noon from 12:00 to 13:00 (Dishub DIY, 2005; 2006). According to transport survey by Dishub DIY (2005; 2006), this phenomenon happens due to the arrangement of office and school hours. The school and office hours mostly start at the same period around 7:15 am to 8:00 am, but they finish at different period of time.

In Sleman Regency, traffic monitoring has just begun at 10 spots in 2005 and 13 spots in 2006. In Kaliurang Street Corridor solely, there was one monitoring spot in 2005 and increased into three spots in 2006 (Dishub DIY, 2005; 2006) (see Table 5.1).

Table 5.1 Traffic Monitoring in Kaliurang Street Corridor, 2005 – 2006

Year	No	Monitoring Spot	Morning		Noon	
			to Yogya	to Kaliurang	to Yogya	to Kaliurang
2005	1	PLN point (km 8)	0.77		0.74	
2006	1	PLN point (km 8)	0.84	0.46	0.44	0.5
	2	MM point (km 4.2)	0.88	0.49	0.62	0.51
	3	GSP point (km 3.5)	0.81	0.58	0.56	0.54

Source: Dishub DIY, 2005; 2006

In order to analyze the V/C ratio in Table 5.1, the Highway Capacity Manual (HCM) in Table 2.7 is utilized. In 2005, the value of V/C ratio in PLN point was established as the median of the total V/C ratio of the traffic flow to the city (to Yogya) and from the city (to Kaliurang) monitored in the morning (0.77) and at noon (0.74). However, in order to perceive the actual condition, the V/C ratio cannot be interpreted by its mean value.

Thus, in 2006, the values of V/C ratio monitored in the morning and at noon were respectively set apart according to the direction of the traffic flow. It can be perceived in Table 5.1 that there are different traffic characteristics during peak hours and off-peak hours in 2006. In the peak hours, the V/C ratio of the traffic flow to Yogya City in PLN point (0.84) and GSP point (0.81) shows the level of service ”D” where the traffic volume is ample but still in the tolerable capacity of the road. The flow of vehicle is intermittent thus almost all drivers have limited vehicle speed. In MM point (0.88), the level has changed to ”E” where there is an excessive traffic volume in the maximum capacity of the road. The traffic flow is irregular with frequent stop of vehicle. Meanwhile, the flow to Kaliurang has level of service ”C” at all points where the vehicle flow is stable but driver still has limited choice in selecting the vehicle speed.

According to Dishub DIY (2005; 2006), level ”A” and ”B” are regarded as normal traffic condition, level ”C” is regarded as fairly normal condition, whereas level ”D” and ”E” are indicating the potential of traffic congestion on the spot. Therefore, it can be assumed that in Kaliurang Street Corridor, the peak hours are in the morning from 6:30 to 8:30 in the direction to Yogyakarta City.

In 2007, the traffic monitoring has been conducted in 15 spots along Kaliurang Street Corridor to observe the traffic factors in urban and rural-urban setting in association with the ambient lead level. The parameters in use are traffic density, travel speed and V/C ratio (see Appendix 19). The state of traffic density, travel speed and V/C ratio are influenced by the number of motor vehicles and the road capacity. For the roadway, the capacity is observed from the geometry of the road, the roadside activity and the street user’s behaviour and the parameter in use to quantify the road capacity is V/C ratio. As an example, the result of traffic counting in urban arterial in Point F is presented in Appendix 20. For the intersection with traffic signal, the capacity can be observed from the arrangement of the traffic light signal period and the parameter in use to quantify the capacity of intersection is Q/C ratio, which is similar to V/C ratio. The method and result of traffic counting for intersection with traffic signal is presented in Appendix 21.

In actual fact, the capacity of the road depends on many factors such as the geometry of the road, the roadside activity and the street user’s behaviour. The geometry of Kaliurang Street Corridor from km 3 to km 17 is almost similar, although each point has different road width. The road has two traffic lanes without any median and it is constructed with fine and smooth asphalt layers. Lack of traffic management and legal instrument to control vehicle speed, road-crossing, roadside parking and roadside stopover has created many conflicts among the street-users thus disrupting the traffic flow and decreasing the vehicle speed. However, the type and impact of the roadside activities and the street user’s behaviour of the road capacity in urban setting may be different with the ones of the road capacity in rural-urban setting.

Following the prior discussion on land use changes, the discussion about traffic and transport condition is also segregated into two sections; first, transportation in urban setting which is represented by the figures of point A, C, F and K; next, transportation in rural-urban setting which is represented by the figures of point H, J, L and P. Exception and additional information from other points shall be adjoined necessarily.

5.5.1 Transportation in Urban Setting

The transportation condition in urban setting is represented by one intersection (point A), and three road sections (point C, F and K). Based on the traffic counting, it is found that the figures of traffic density in those four points are beyond the average 1.415 veh./m^2, except for point F (0.82 veh./m^2) and K (0.9 veh./m^2). And in all four points, the travel speed is fairly far below the average 2.05 m/s. It indicates a very slow movement of traffic flow, far below the standard of vehicle speed in peak hour for a medium city (6.72 m/s). In point A, the high traffic density is mostly contributed from the north lane which is coming from Depok District to Yogyakarta City. This intersection plays a great role as the transportation node in Yogyakarta Urban Area because all of public transport will pass through this area, some spots in the intersection have been developed as a "publicly-agreed" bus stop which is, in practice, very much disrupting the traffic flow (see Figure 5.8).

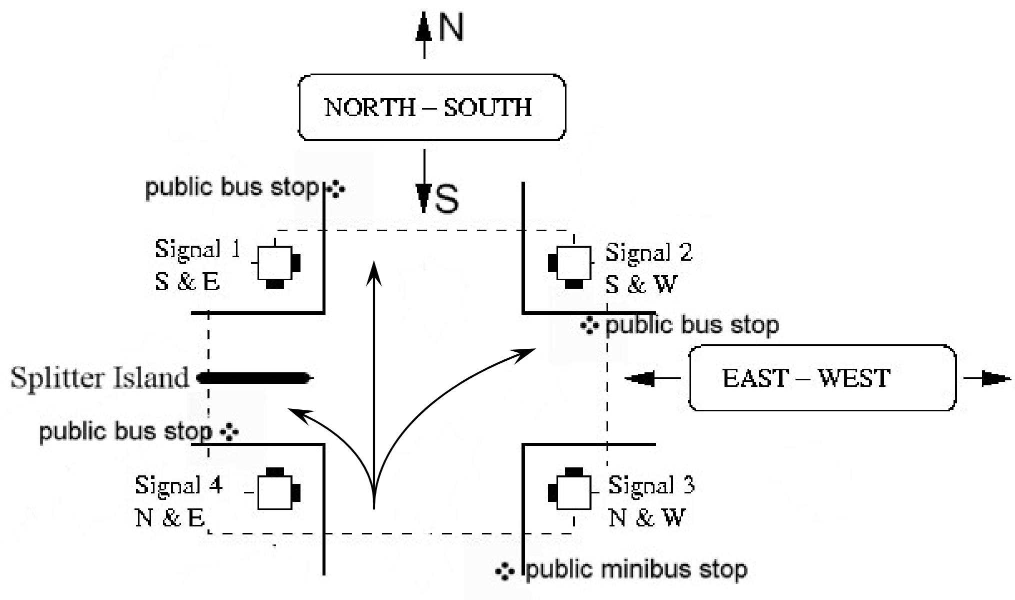


Figure 5.8 The Geometry of Intersection in Point A
Source: Developed from www.isr.umd.edu

Moreover, the slow movement of traffic flow has been caused by the disruption from the presence of un-motorized vehicle as well as roadside parking (see Figure 5.9).

Figure 5.9 The Roadside Activities in Point A

Meanwhile, the road geometry of point C, F and K are fairly similar except for the road width (W_c) and the width of the road shoulder (W_k), as illustrated in Figure 5.10. The road width in point C is 10 m, whereas the width of the road shoulder is 1 m. Meanwhile, in point F and K, the road width and the width of the road shoulder are fairly similar, which are respectively 7 m and`60 cm.

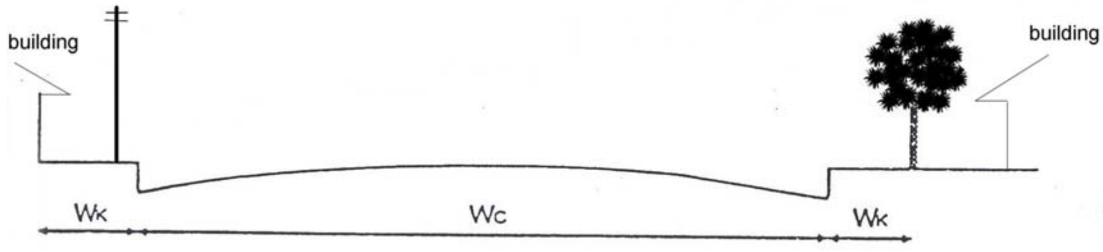


Figure 5.10 The Geometry of Kaliurang Street in Urban Setting
Source: Developed from MKJI, 1997

The roadside activities are also present in these road sections such as the unmotorized vehicles in point C (see Figure 5.11), which may slow down the motorized vehicle speed to the very low speed close to idle engine. Thus, it will increase the emission from incomplete engine combustion.

Figure 5.11 The Garbage Cart and Bicycle in front of Gading Mas Minimarket (point C)

Furthermore, parking on the roadways in point F is also disrupting the traffic flow in the peak hours, since the activity in the market starts in the morning (see Figure 5.12).

Figure 5.12 Parking on the Roadside in Colombo Market (point F)

Meanwhile, the behaviors of the street users, with and/or without vehicles also have potential to be a nuisance for the traffic flow such as the street-crossers with and/or without vehicles, which recklessly cross the street at any place and any time on the roadway, as shown in Figure 5.13.

Figure 5.13 The Reckless Street-crosser with Motorbike in Kentungan Intersection (point D)

Those roadside activities in those four points have been influencing the quantification of V/C ratio in each point. The result shows the V/C ratio in point A and F are respectively 0.88 and 0.86 which are in the level of service ”E”, where there is an excessive traffic volume close to the maximum capacity of the road. Thus, the traffic flow is irregular with frequent stop of vehicle. Meanwhile, the V/C ratio in point C and K are respectively 0.76 and 0.75 which are in the level of service ”D”, where the traffic volume is ample but still in the tolerable capacity of the road. The traffic flow is nearly irregular so that almost all drivers have limited vehicle speed. Both level “D” and “E” has indicated that there is an occurrence of traffic congestion because of the excessive traffic volume and lacking of road capacity.

5.5.2 Transportation in Rural-Urban Setting

The transportation condition in rural-urban setting is represented by one intersection (point J), and three road sections (point H, L and P). Based on the traffic counting, it is found that the figures of traffic density in point H, L and P are respectively 0.85 veh./m^2, 0.70 veh./m^2 and 0.34 veh./m^2, thus they are far below the average 1.415 veh./m^2. And the travel speed of those three points is found considerably far beyond the average 2.05 m/s, which are respectively as follows 3.43 m/s (point H), 3.01 (point L) and 5.95 (point P). The road geometry and the road width in point H, L and P are similar (see Figure 5.14).

The figure of traffic density and travel speed have been influenced by the figure of building density in similar points which indicates low human activity on the area, thus it also lessens the growth of economic development as well as the travel needs. The less economic growth has maintained the maximum capacity of the road since there will be less roadside activity on the area. Furthermore, as the need to travel decreased, number of vehicles is also decreasing.

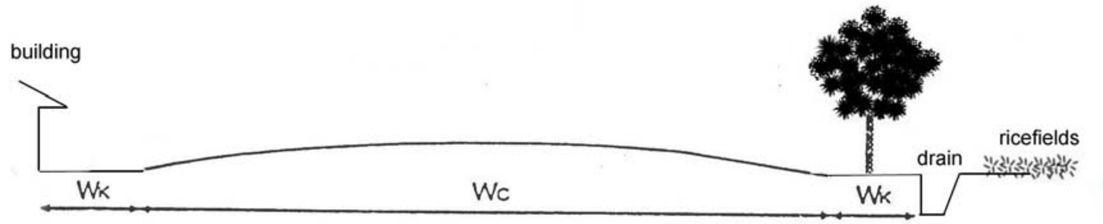


Figure 5.14 The Geometry of Kaliurang Street in Rural-Urban Setting
Source: Developed from MKJI, 1997

However, there is an exception in point J which is a 3-legged intersection connecting Kaliurang Street with the first exclusive housings in the northern fringe, Merapi View Residents (see Figure 5.15). The traffic density and the travel speed in point J are respectively 1.48 veh./m^2 and 2.00, which are approximately on the average. The commercial activity in point J is fairly intensive although the figure of building density is low, thus the traffic condition is on the average.

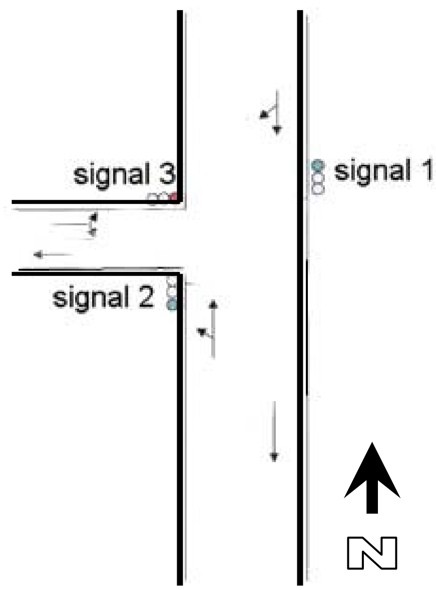


Figure 5.15 The Geometry of T-junction of Merapi View (point J)
Source: Developed from www.cycling.org.sg

The findings have also been verified with the quantification of V/C ratio in each point. The V/C ratio in point H, L and P are respectively 0.30, 0.28 and 0.28 which show level of service "B", where the traffic flow condition is stable. Thus, the drivers may have selection of vehicle speed in tolerable level. Meanwhile, the V/C ratio in point J is 0.55 which shows level of service "C", where the traffic flow is stable but there is limited choice in selecting the vehicle speed. Both level "B" and "C" has indicated a fairly normal traffic flow condition because the traffic volume is still below the capacity of the road. This is also because there is a trivial presence of roadside activities.

5.6 Ambient Lead Monitoring

In order to observe the ambient air quality, the parameter in use is ambient lead (Pb) level since the lead gasoline is still widely distributed in Yogyakarta Urban Area (ADB, 2006). Ambient air quality monitoring, particularly of Pb level, has been regularly done since 2001 in Sleman Regency. The monitoring spots are increasing every year. In the beginning, there were only four spots, but then in 2006 they increase to eight monitoring spots in Kaliurang street corridor alone (KPDL Sleman, 2006; BAPEDALDA DIY, 2007). In 2006, there were two monitoring spots recorded over limit ambient Pb-concentration (see Table 5.2).

Table 5.2 Ambient Monitoring of 1hr-Pb Concentration from 2001 to 2006
in Kaliurang Street Corridor

No	Monitoring Spot	**Ambient 1hr-Pb Concentration** (in μg/m^3)					
		2001	**2002**	**2003**	**2004**	**2005**	**2006**
1	T-junction of Pakem Market	0.844	0.06	0.512	1.01	0.44	–
2	In front of UII	–	–	–	–	–	–
3	T-junction of Merapi View	–	–	–	–	–	–
4	T-junction of Colombo Market	–	–	–	–	–	–
5	Tina Farma Drug Store	–	0.46	2.06	1.37	0.47	2.94
6	4-junction of Kentungan	0.835	0.14	0.485	1.86	0.18	0.471
7	4-junction of MM UGM	–	–	–	–	–	1.854
8	4-junction of Mirota Supermarket	–	0.59	1.67	1.58	0.59	2.42

Note: Emission Standard = 2 μg/m^3
Source: BAPEDALDA DIY, 2006

In 2007, the monitoring of ambient lead level has been done in 15 sampling points. The result of the monitoring is presented in Appendix 22. It will be discussed in two sections which are ambient lead level in urban setting and in rural-urban setting.

5.6.1 Ambient Lead Level in Urban Setting

From the field monitoring it is found that the level of ambient lead in urbanized area is close to the Pb emission standard in Indonesia (2.00 μg/m^3). It is represented in point A (1.773 μg/m^3), C (1.058 μg/m^3), F (2.00 μg/m^3), K (1.057 μg/m^3) and Q (1.539 μg/m^3). This result due to the high figure of building density and the assortment of activities which trigger more travel needs thus increase the traffic density and high level of Pb emission. The presence of roadside activity also contributes a great deal to the result. It causes traffic congestion which is increasing the Pb emission to the ambient air.

Moreover, it has been exaggerated by less of trees which can adsorb the Pb particles on the roadside. In Kaliurang Street Corridor, the land along the roadside is very valuable, thus the owner shall make the most benefit of it. The presence of vegetation will lessen the space for business. Thus, the land use changes in urban setting does not consider about green space anymore.

5.6.2 Ambient Lead Level in Rural-Urban Setting

In rural-urban area, the level of ambient lead is relatively low. It is represented in point H (0.086 μg/m^3), J (0.550 μg/m^3), L (0.046 μg/m^3) and P (0.014 μg/m^3). Even though similar roadside activities as in urban setting are presence in rural-urban setting, they are not exaggerating the Pb emission to the ambient because the traffic volume is considerably low. Thus, the level of service of the road indicates a normal condition of traffic flow.

Moreover, the land use changes in rural-urban area are fairly dormant and the function of the building is not creating more travel needs. Thus, the mobility of people is low and it discharges small amount of Pb to the ambient air. Furthermore, the presence of slightly more vegetation than in the urban setting on the roadside has helped adsorbing the discharged Pb particles.

5.7 Concluding Remarks

According to the BAPPEDA Sleman (2006), the leap frog development in the northern fringe has triggered a considerably excessive traffic generation. This has increased the number of motorized vehicle since the public transport is inadequately provided. Moreover, this also raised the ambient lead pollution issue due to vehicular emission since the lead gasoline is still widely distributed in Yogyakarta Urban Area. In Sleman Regency, the ambient lead monitoring has been performed since 2001. In 2006, two monitoring stations in Kaliurang Street have shown over limit level of ambient lead.

It has become a serious concern of the municipality in dealing with the transport planning and management, particularly the road network development. However, due to the financial and technical issues, the road network development cannot promptly follow the pace of land use changes. As a result, in some spots, traffic congestion cannot be avoided since the road capacity is no longer sufficient to accommodate the excessive traffic volume. According to Ammari (2005) the traffic congestion has exaggerated the vehicular emission to the ambient air. This phenomenon has been verified in 2007 through traffic counting and ambient lead level monitoring in 15 sampling location along Kaliurang Street Corridor. The result shows, the ambient lead level is considerably high on the spots that have potential traffic congestion.

Chapter 6

Correlation of Land Use Changes and Transportation to the Ambient Lead Level

This chapter provides the quantitative verification of the relation of land use and transport factors to the ambient lead level based on the field survey and observation in 15 selected sampling locations which represent Depok, Ngaglik and Pakem District along Kaliurang Street Corridor.

6.1 Multiple Linear-Regressions with OLS Method Analysis

In order to verify in what way and to what extent land use changes and transportation factors are correlated to ambient Pb level, multiple linear-regressions with Ordinary Least Square (OLS) method is utilized. This method is able to estimate the regression coefficient as well as ensures that the results have "BLUE" characteristics, stands for Best, Linear and Unbiased Estimator. The estimators for land use changes are building density and roadside vegetation, whereas the transportation factors are traffic density, travel speed and the V/C ratio. The result of regression is presented in Table 6.1, whereas the complete result is presented in Appendix 23.

Table 6.1 The Regression Result of land use changes and transportation factors to Ambient Lead Level (OLS method)

Variable	Regression Coefficients	t-value	P-value
Constant	- 0.166	- 0.102	0.921
Ln_Building Density	0.137**	1.677	0.128
Ln_Roadside Vegetation	- 0.026	- 0.334	0.746
Ln_V/C Ratio	0.655***	6.310	0.001
Ln_Traffic Density	0.076*	0.905	0.389
Ln_Travel Speed	- 0.199**	- 1.705	0.122
F-test value		73.586	0.001
No. of sampling point = 15 R-Square = 97.6% Adj. R-Square = 96.3%			

Note: *** significant at 99% level of CI
** significant at 87% level of CI
* significant at 61% level of CI

The regression result on Table 6.1 can be explained as follows:

1. Based on the F-test value, all of the estimators are collectively correlated to the Ambient Lead Level, and the correlation is significant at 99% level of CI.
2. The R-Square value is 97.6% and the adjusted R-square value is 96.3%. This means 97% of Ambient Lead Level is influenced by land use changes and transportation factors. Thus, it can be verified that the correlation of land use changes and transportation factors as the independent variables and ambient lead level as the dependent variable has been best-fit established in the model.
3. The Constant value has negative score (-0.166) and not significant (P-value = 0.921). In this study, it means the score of ambient lead level is close to zero if the presence of

all estimators is constant. Thus, it can be inferred that if the land use changes and transportation factors are in control, the increase of lead emission to the ambient air will also be in control.

4. Parameters with negative score are Roadside Vegetation (- 0.026) and Travel Speed (-0,199) which are respectively influential and significant at 25% and 88% level of CI. It shows that the assumed correlation has been verified although they are not significant at $\propto = 0.05$ and $\propto = 0.01$.

   Even though the association to Ambient Lead Level is presence, Roadside Vegetation has poor significant level because the existing quantity of vegetation crown's density was not sufficient to describe the magnitude of the association. Lack of vegetation in sampling area is because of uncontrolled land use changes from green lands to paved and/or built up entity without leaving any space for trees. Moreover, the type of vegetation which can effectively adsorb the lead particles is poorly identified in the quantification. These has affected the statistical analysis and revealed only small number of significance level. Meanwhile the considerable significant level of Travel Speed has verified that the decelerated engine will discharge more lead emission from incomplete combustion.

5. Parameters with positive score are V/C Ratio (0.655), Building Density (0.137) and Traffic Density (0.076) which are respectively influential and significant at 99%, 87% and 61% level of CI. It shows that the assumed correlation has been verified although only V/C Ratio is significant at $\propto = 0.01$, hence it has BLUE characteristic.

   V/C Ratio has BLUE characteristic because it is well-characterizing the level of congestion from the transportation factors and land use allocation. This has verified that the traffic congestion is exaggerating the lead pollution to the ambient air. V/C Ratio represents the volume of motorized vehicles and the capacity of road as one of the vital elements in land use allocation.

   The poor significant level of Traffic Density is because it is assumed that 95% of motorized vehicles including passenger cars and motorbikes are using leaded fuel. In the realm of the car-manufacture technology, after 2000 the car engines have been designed to operate using unleaded gasoline. However, in practice, there is uncertainty about the unleaded gasoline users, since the price is high and the availability of unleaded gasoline is tentative. Meanwhile, the statistical analysis of Building Density revealed a modest significant level because it has indirectly induced the ambient lead level through transportation factors.

Chapter 7

Conclusion and Recommendation

This chapter is the remaining part which consists of conclusion and recommendation. The conclusion will provide summary of the findings in the study, whereas the recommendation will provide the lesson learnt and suggestion to deal with ambient lead pollution as well as the suggestion to the improvement of further study in the similar course.

7.1 Conclusion

This research project studies the correlation of land use changes to the ambient lead level in peri-urban area of Yogyakarta City, Indonesia through the following perspective: GIS application, field survey and statistical analysis. The major findings are highlighted according to the above three sections.

7.1.1 Major Findings

The land use mapping and interpretation from Quickbird Image 2005 and DigitalGlobe Image 2007 using GIS tools has accurately illustrated the characteristic of Leap Frog Development in in Kaliurang Street Corridor in km 3 to km 17 in north peri-urban area of Yogyakarta City. The phenomenon has also been deliberately represented in the figure of Building Density in the selected sampling location. Moreover, the leap frog characteristics are verified with ground truth observation.

From the land use mapping, the sampling points which have high building density figure are showing the characteristics of urban setting. The organization of building is solid and compacted with very rare agricultural land, whereas the configuration of built up area is well-shaped in geometrical form. Based on the ground checking, the lands along the road are fully occupied with commercial buildings which facilitate the urban lifestyle with less space for parking and greeneries.

Meanwhile, the sampling points which have low building density figure are showing the characteristics of rural-urban setting. Although the buildings are well-shaped in geometrical form, the organization of buildings is dispersed sporadically within the generously proportioned agricultural lands, which shows the nature of leap frog type development. Based on the ground checking, the lands along the road are randomly occupied by exclusive residences and commercial buildings which also facilitate the urban lifestyle with adequate space for parking and greeneries.

Based on the result from questionnaire, it is revealed that the ultimate driving forces of the land use changes are the presence of the two universities in the peri urban area and the presence of Kaliurang Recreation Park that attract many education and tourism related business along the street, thus change the agricultural lands into shops or any commercial use. Moreover, the enhancement of asphalt layers on the road has also trigger the economic development which is exaggerating the land use changes. From the environmental perspective, the land use changes have affected the traffic flow in Kaliurang Street Corridor and exaggerate the ambient lead emission on the roadside. This has been verified by the field measurement in 2007.

The high level of ambient lead (1-2 µg/m3) is found in the location with high figure of Building Density (>50%) with low figure of Roadside Vegetation, where the V/C ratio is showing the high level of traffic congestion. Based on the field observation, the Traffic Density is high and the Travel Speed is far below the vehicle speed standard in medium city (<< 6.72 m/s). Meanwhile, the low level of ambient lead (>0.1µg/m3) is found in the location with low figure of Building Density and Roadside Vegetation, where the V/C ratio is showing the low level of traffic congestion. Therefore, although the field observation shows that the Traffic Density is high, the Travel Speed is fairly close to the standard.

The correlation of land use changes and ambient lead level is verified statistically using multiple linear regressions with Ordinary Least Square (OLS) method. The parameters in use are Building Density, Roadside Vegetation, V/C Ratio, Traffic Density and Travel Speed. Those five parameters have been observed in the selected sampling locations to fulfill the statistical requirements. From the regression result, it is revealed that 96% of ambient lead level is influenced by all five parameters, where as the F-test has revealed that all five parameters are collectively significant in $\alpha=0.001$.

Meanwhile, in partial, the t-test has revealed that the most significant parameter correlated to ambient lead level is V/C Ratio ($\alpha=0.001$) with positive connection, consecutively followed by Travel Speed (P-value = 0.122) with negative connection, Building Density (P-value = 0.128) with positive connection, Traffic Density (P-value = 0.389) with positive connection and the less significant parameter, Roadside Vegetation (P-value = 0.746) with negative connection. Moreover, the t-test has also revealed that the value of Constant has no significant influence to the ambient lead level because its P-value is 92%.

7.2 Recommendation

The recommendation is highlighting the lessons that can be learnt from this study as a contribution to the urban planners and decision makers in order to deal with the ambient lead pollution due to motorized vehicles.

7.2.1 Lesson Learnt

Based on the findings, it is identified that V/C Ratio is the best parameter to observe the correlation of land use changes to the lead level in the ambient air. V/C Ratio has a positive correlation with ambient lead level which means the level of ambient lead will go in parallel with the value of V/C Ratio. Therefore, in order to control the ambient level, planners should address the elements that involved in V/C Ratio parameter that contribute to making urbanized area a pleasant place to live and work, which are including Traffic Volume and Road Capacity. The low level of V/C Ratio can be obtained if Traffic Volume is decreased and the Road Capacity is enhanced. In order to deal with that, a combination of command and control shall be necessarily administered.

In order to lessen the Traffic Volume as well as enhance the Road Capacity, some of the findings of this study can be considered as recommendations. First, the use of motorized vehicle should be discouraged with specific planning and design such as provide a roadside pavement for the pedestrian and bikers. However, based on the field observation in 2007, the paved roadside will invite people to establish informal business which also encourage parking activity on the street, whereas the roadside with uncovered drain is free from any activity. Thus, the provision of roadside pavement should be simultaneously strengthened by proper legal instruments by the government thus the pavement will not be occupied by any informal sectors which encourage parking on the street. Moreover, the behavior of street users toward the paved or unpaved roadside can also be considered in designing the urban space, thus the disruption to traffic flow will be diminished. If the disruption is diminished, the traffic flow is expected to be normal thus the next significant parameter, Travel Speed, will be getting close to the standard.

Meanwhile, although it is moderately significant, the Building Density has positive correlation to the ambient lead level since it triggers more mobility with motorized vehicles, particularly for the building alongside the road which are mostly occupied for commercial use. Therefore, in order to control the ambient lead level, the land use changes from green lands to the built up area shall be controlled using a proper land use planning as a development control which must be strengthened by a combination of legal instruments and economic instruments. Moreover, it may need further observation to the intensity of traffic activity in the building alongside the road to see the how far the building influences the number of vehicles in Kaliurang Street Corridor.

The combination of legal instruments and economic instruments is also applicable for the least significant parameter, Roadside Vegetation. Although it is not statistically significant, Roadside Vegetation has a negative correlation to the ambient lead level. This means that the quantity of Roadside Vegetation is going in the opposite with the level of lead in the ambient air.

In order to decrease the level of ambient air, the amount of vegetation on the roadside need to be increased. Thus, the government should encourage the greening action alongside the roadway with great consideration to the type and quantity of the tree that can effectively adsorb the lead particles as well as for the benefit of street beautification which follow the criteria of Fandeli et al (2004) and Fakuara (1991). For example, an economic instrument can be employed to encourage the entrepreneurs along the roadside to allocate some of their front yard for greeneries.

All the recommendation from this study will only be practical with the strong political will from the government to encounter socio-economic development without ignoring the protection to the environment thus Yogyakarta Urban Area can be further developed to be a livable city.

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APPENDIX

Appendix 1 – Picture of 15 Sampling Points in Kaliurang Street Corridor

(i)

(ii)

(iii)

(iv)

(v)

(vi)

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(viii)

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(x)

(xi)

(xii)

(xiii)

(xiv)

(xv)

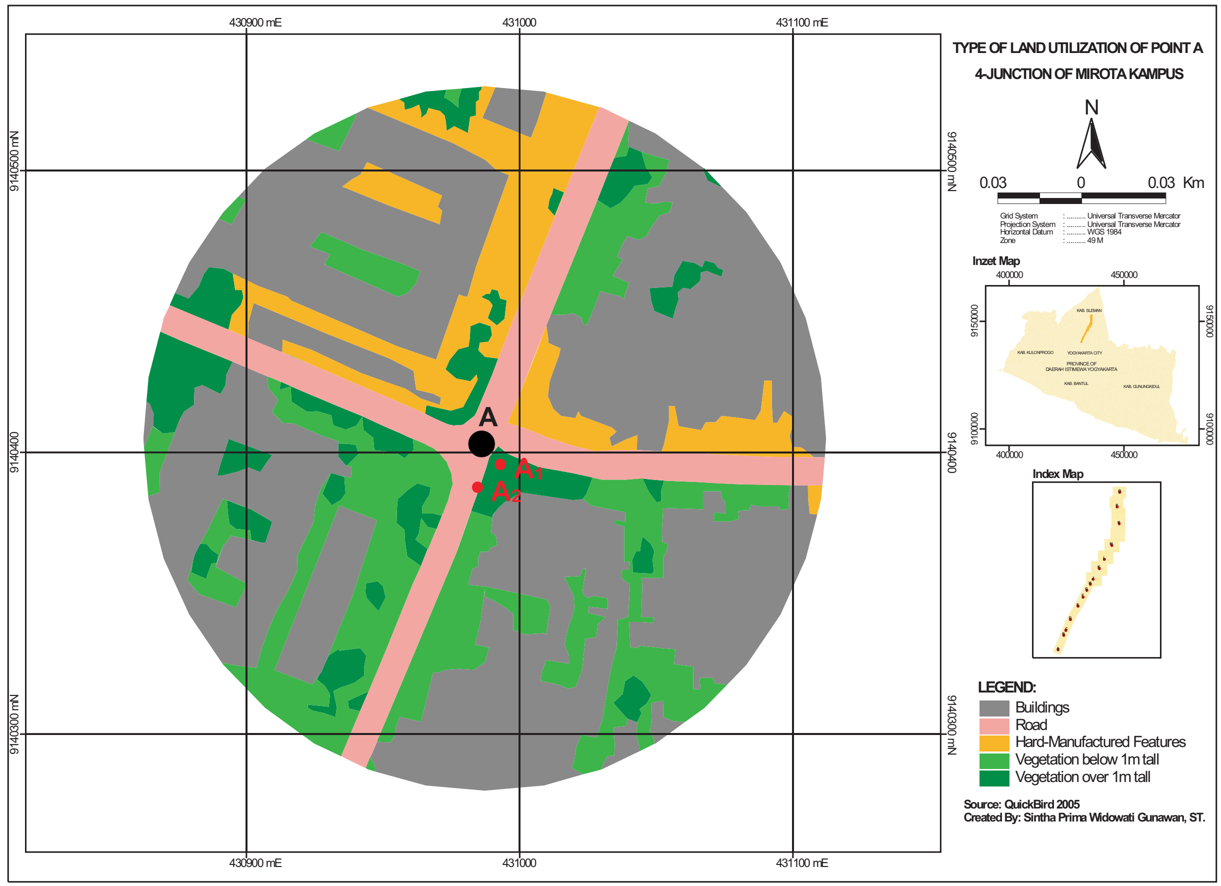
Appendix 2 – Statistical Figure of Building Density and Roadside Vegetation of 15 Sampling Locations in Kaliurang Street Corridor from Land Use Mapping 2007 using Quickbird Image 2005 and DigigtalGlobe Image 2007

Sampling Point (*n=15*)	Distance to City	Building Density	Roadside Vegetation
	km	(%)	m^2
Point A: 4-junction of Mirota Kampus Supermarket	0.0	52.41	2345.87
Point B: 4-junction of MM UGM	1.5	27.25	9481.60
Point C: In front of Gading Mas Minimarket	2.2	65.99	255.01
Point D: 4-junction of Kentungan	2.8	44.40	1965.28
Point E: In front of Tina Farma Drugstore	3.4	44.98	2512.59
Point F: In front of Colombo Market	3.7	64.88	1559.12
Point G: In front of PLN (Regional Power Plant)	4.8	41.35	3263.93
Point H: In front of Social Agency Book Store	5.5	29.08	4765.24
Point J: T-junction of Merapi View	6.0	18.94	2140.18
Point K: In front of Gentan Market	8.0	53.49	2183.16
Point L: In front of WS Minimarket	8.5	10.79	3535.10
Point M: In front of Toraja Sea Food Restaurant	10.0	36.40	5886.89
Point N: In front of UII Campus	11.2	39.53	2029.41
Point P: In front of Mirota Batik	12.7	6.77	9198.24
Point Q: In front of Pakem Market	14.0	65.86	2013.82

Appendix 3 - Point A: 4-junction of Mirota Kampus Supermarket

(ii) point A1

(iii) point A2

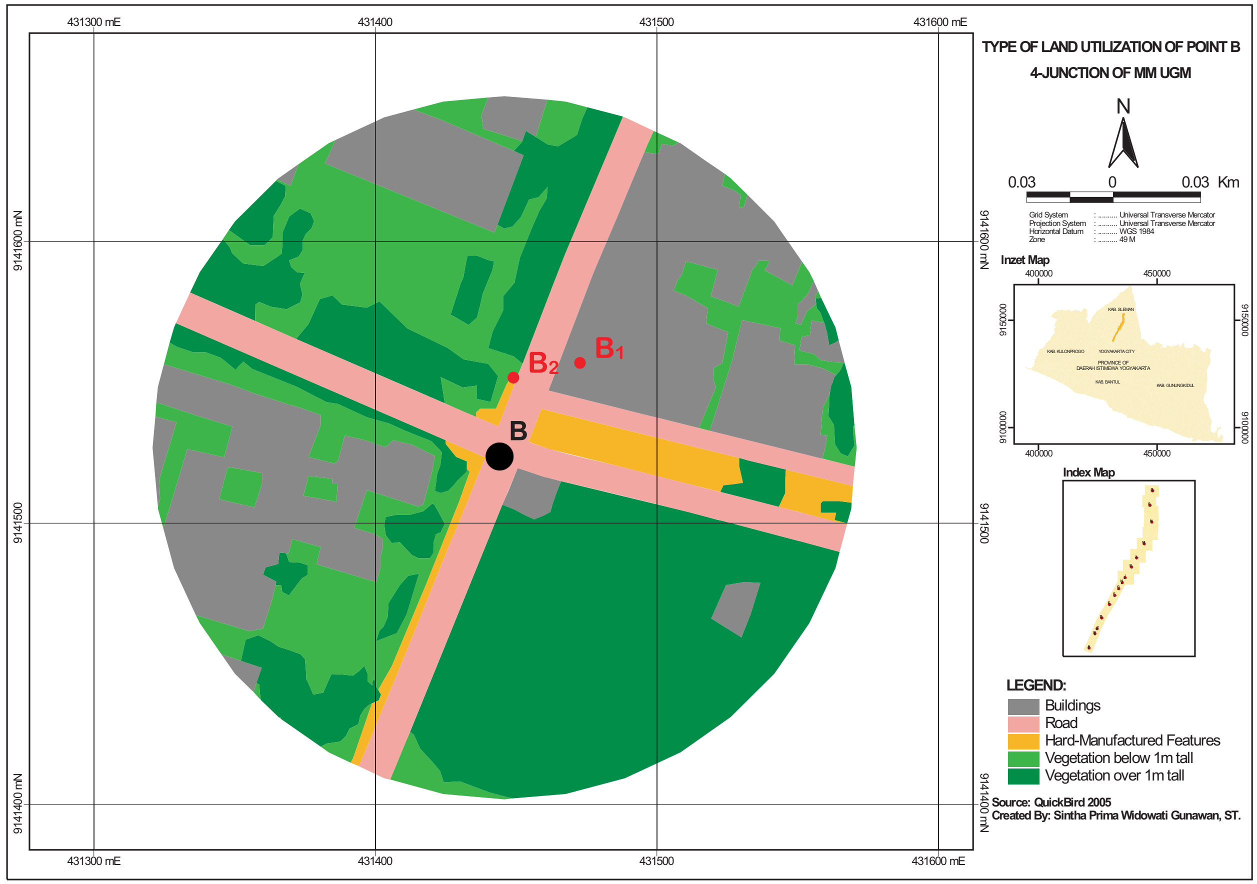


(i) Land Use Map of Point A

Appendix 4 - Point B: 4-junction of MM UGM

(ii) point B1

(iii) point B2

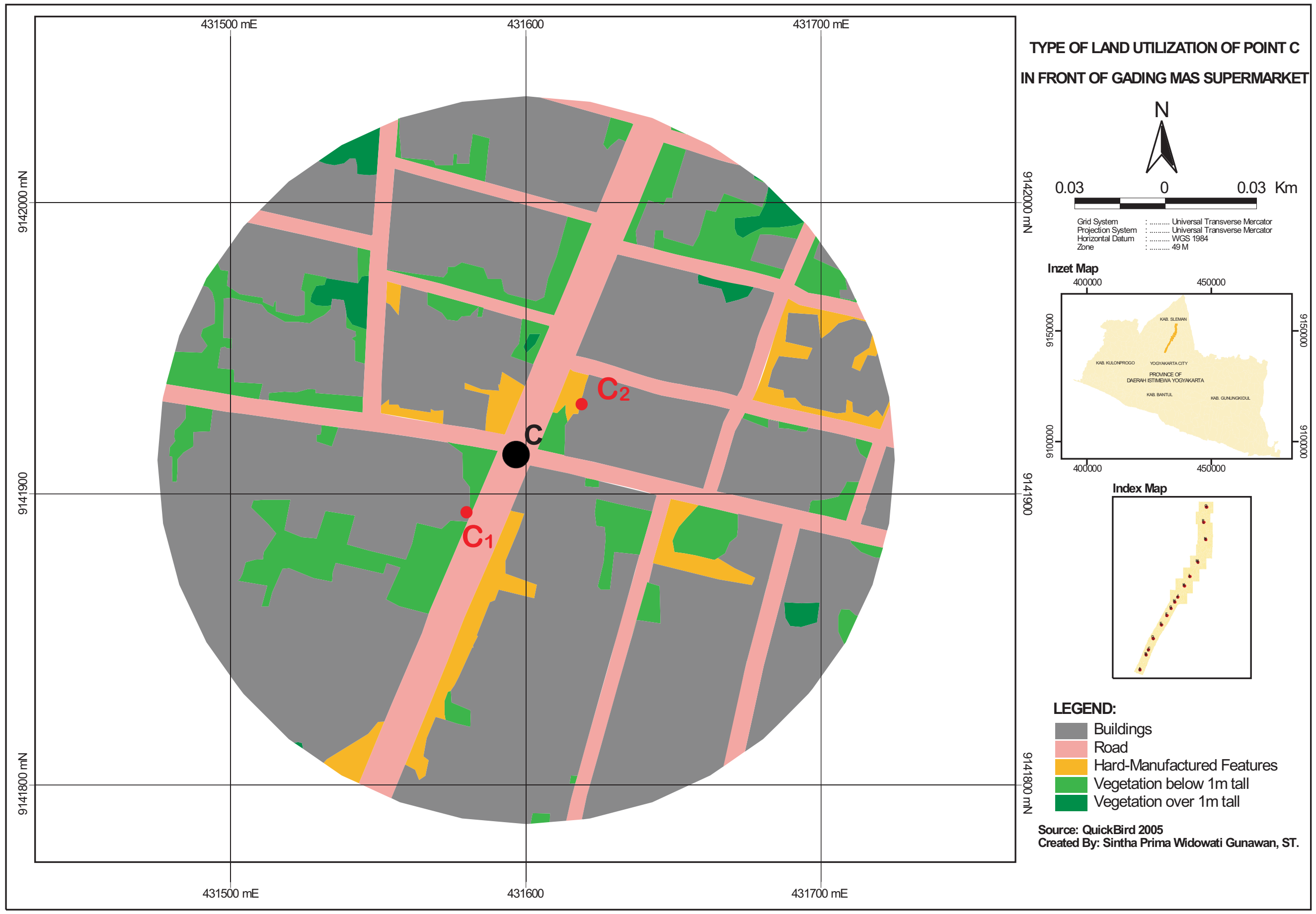


(i) Land Use Map of Point B

Appendix 5 - Point C: In front of Gading Mas Minimarket

(ii) point C1

(iii) point C2



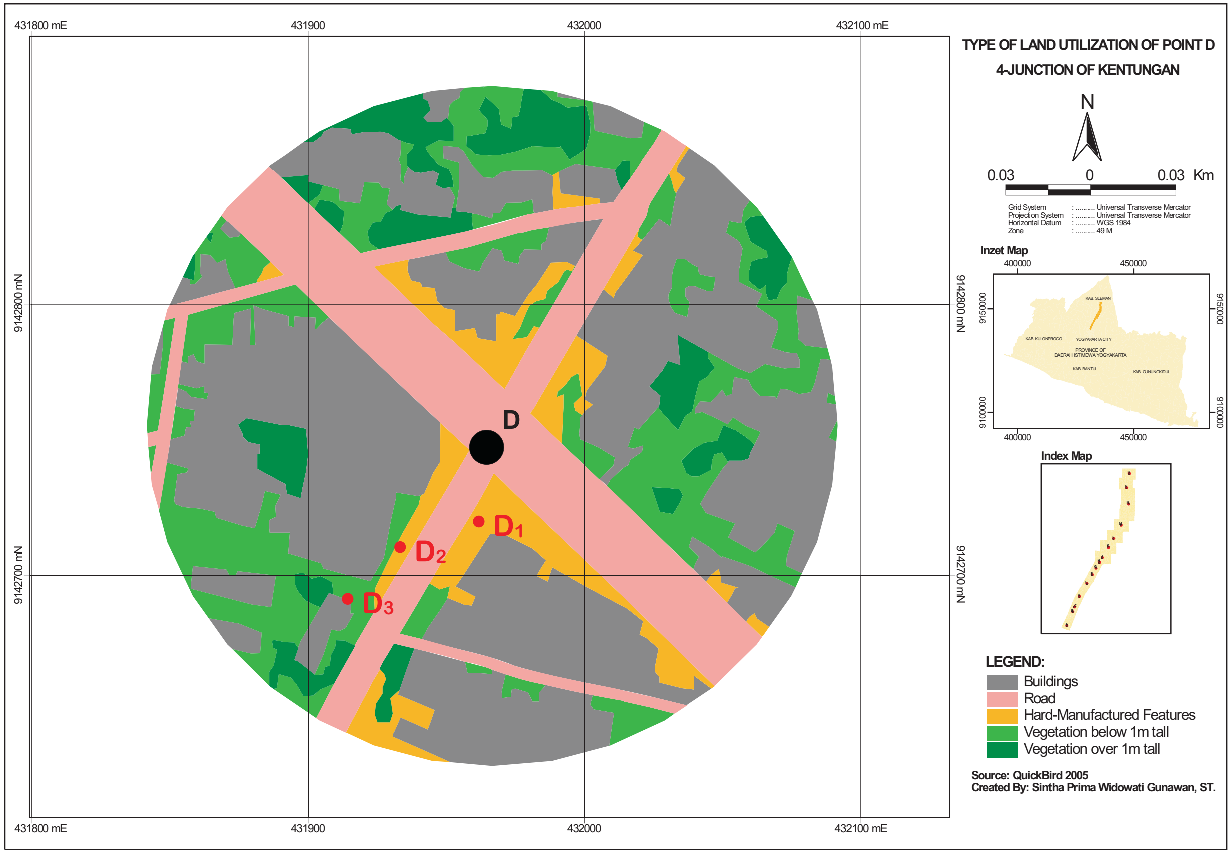
(i) Land Use Map of Point C

Appendix 6 - Point D: 4-junction of Kentungan

(ii) point D1

(iii) point D2

(iv) point D3

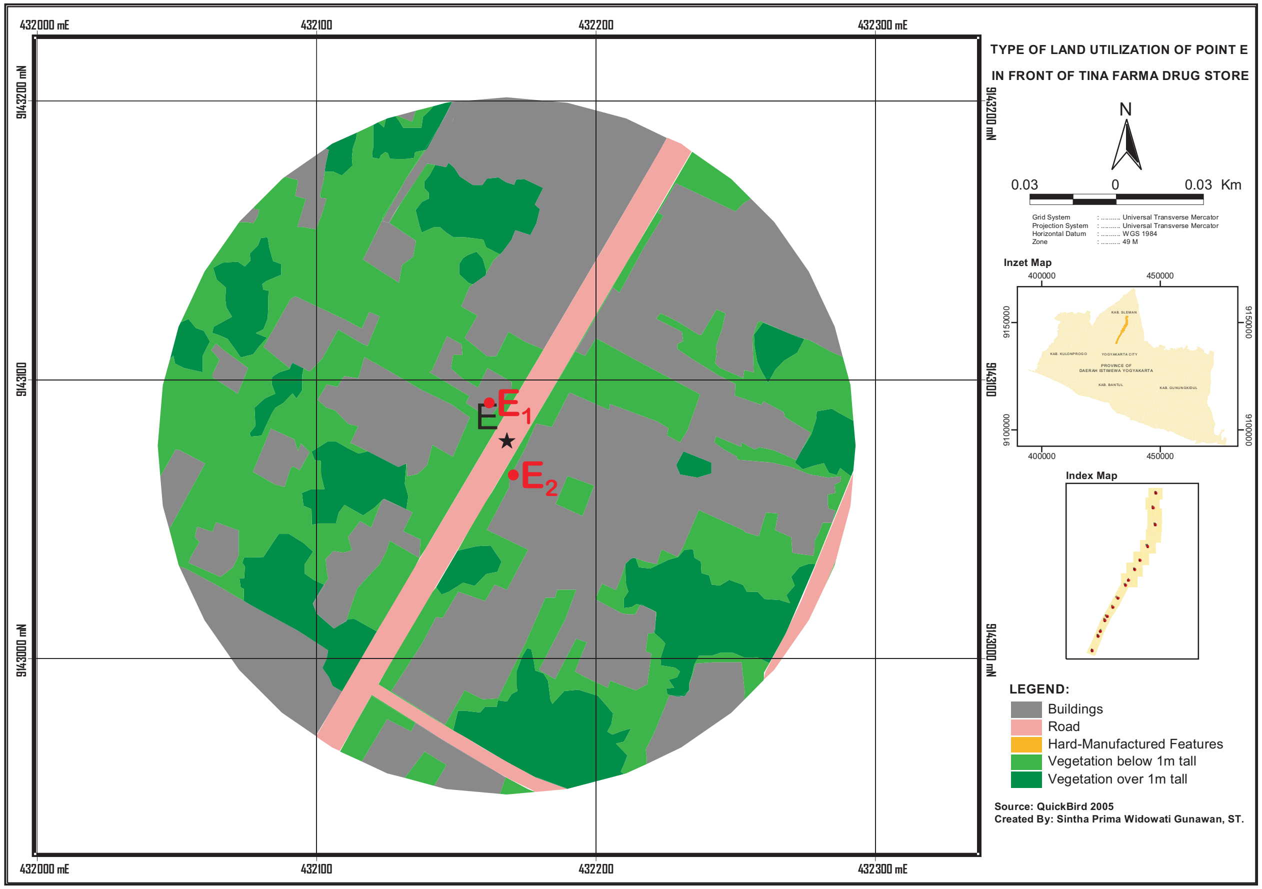


(i) Land Use Map of Point D

Appendix 7 - Point E: In front of Tina Farma Drugstore

(ii) point E1

(iii) point E2

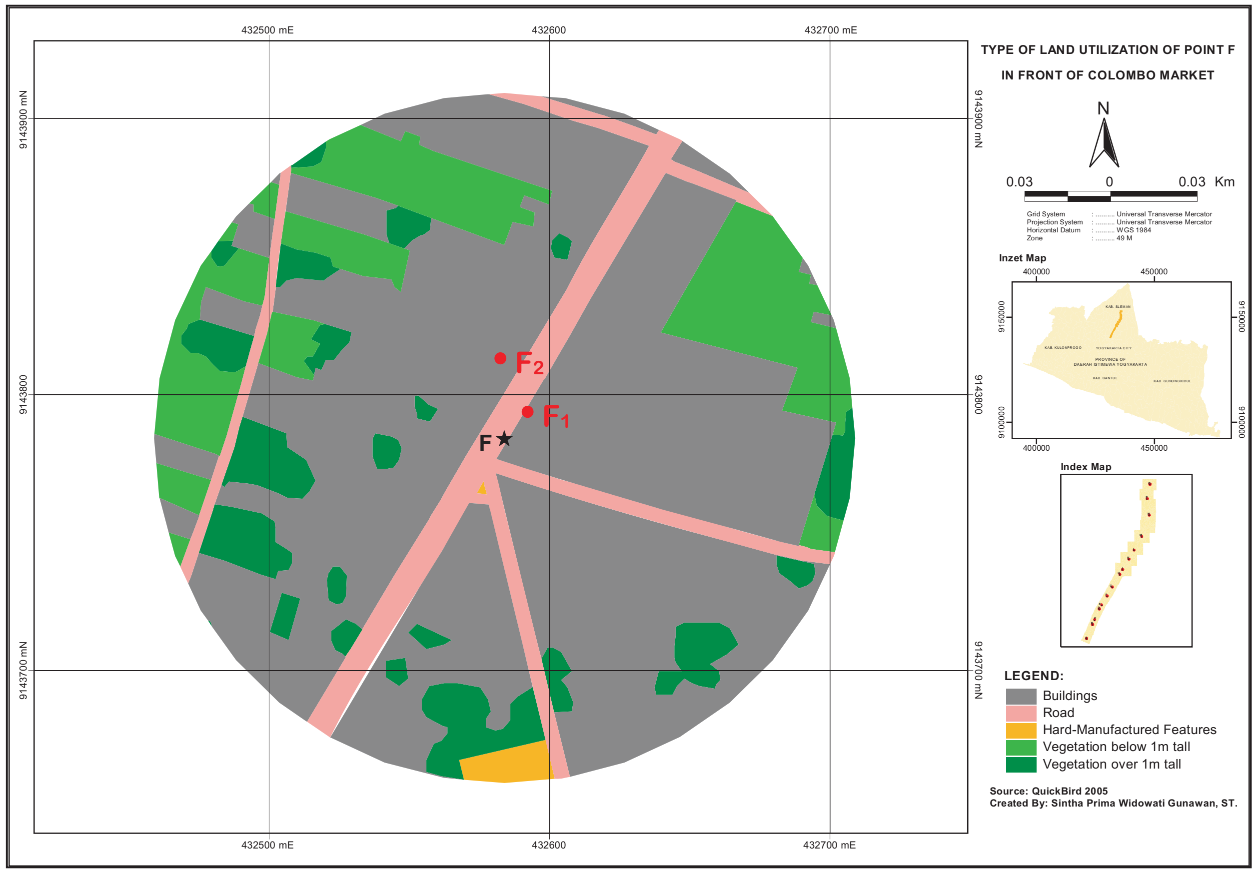


(i) Land Use Map of Point E

Appendix 8 - Point F: In front of Colombo Market

(ii) point F1

(iii) point F2

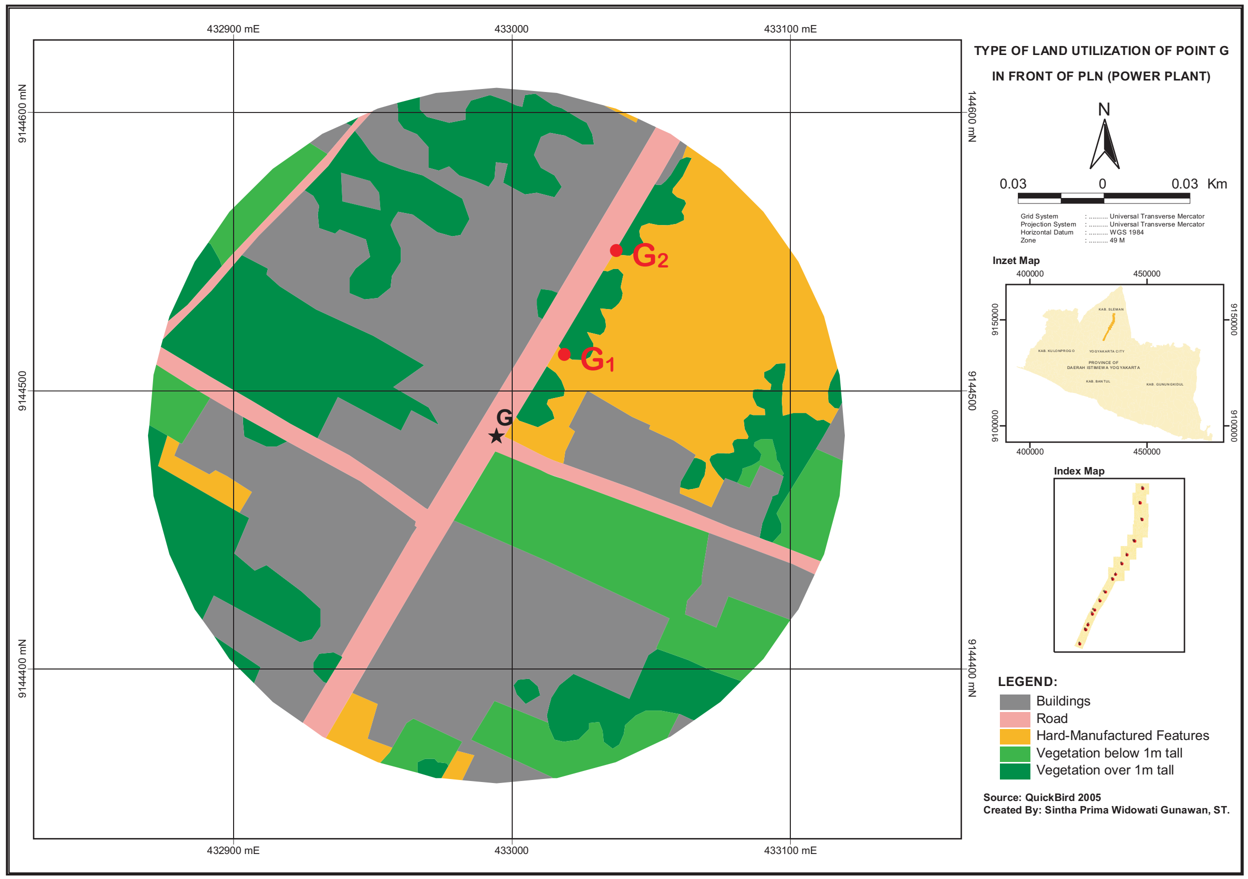


(i) Land Use Map of Point F

Appendix 9 - Point G: In front of PLN (Regional Power Plant)

(ii) point G1

(iii) point G2

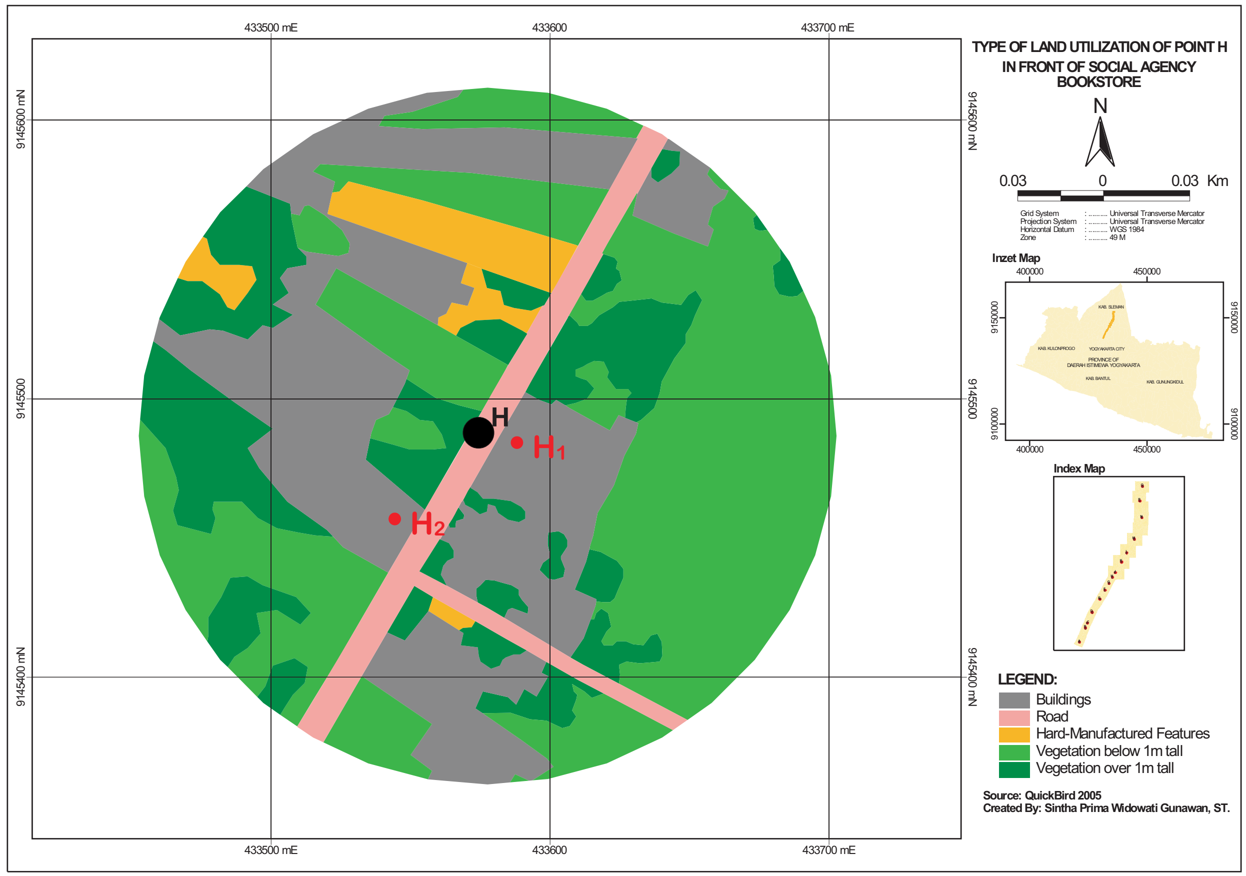


(i) Land Use Map of Point G

Appendix 10 - Point H: In front of Social Agency Book Store

(ii) point H1

(iii) point H2



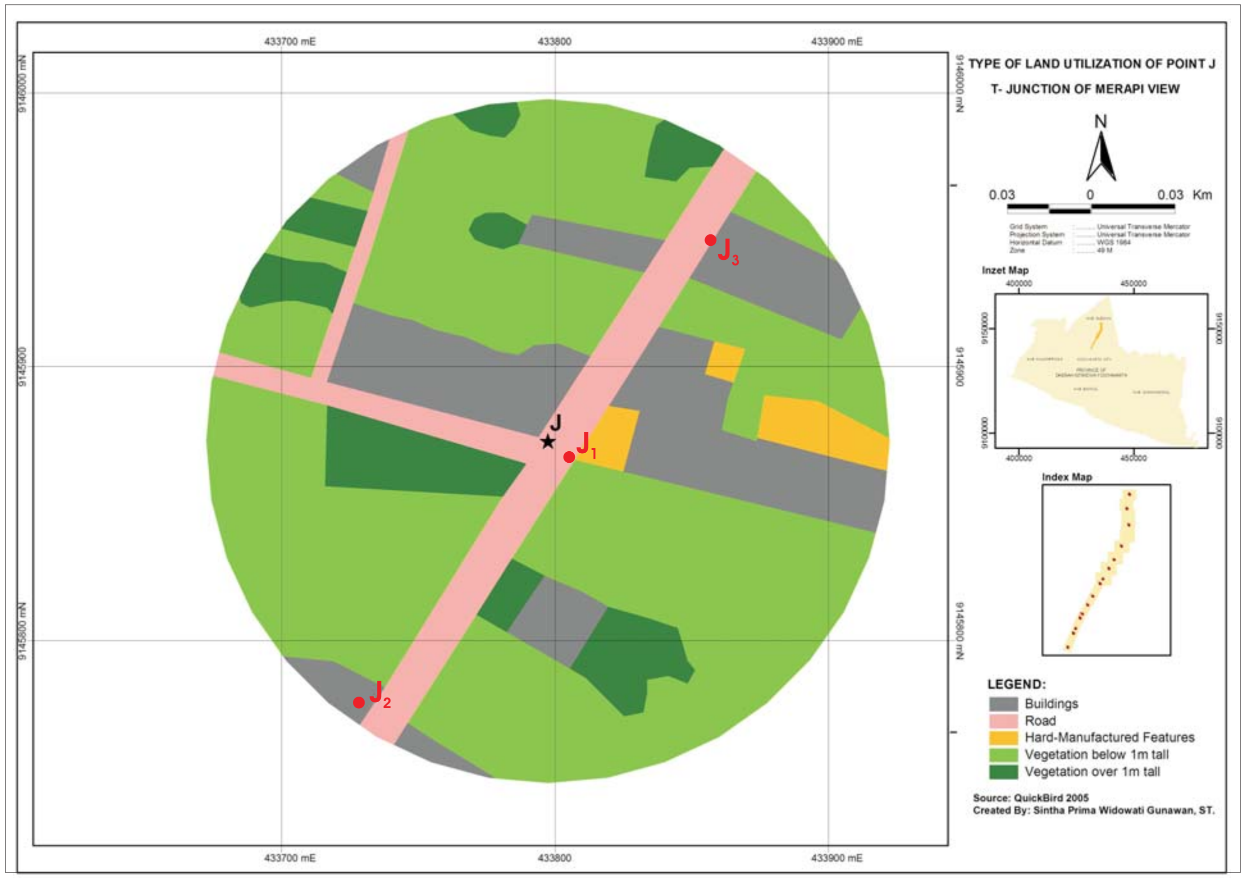
(i) Land Use Map of Point H

Appendix 11 - Point J: T-junction of Merapi View

(ii) point J1

(iii) point J2

(iv) point J3

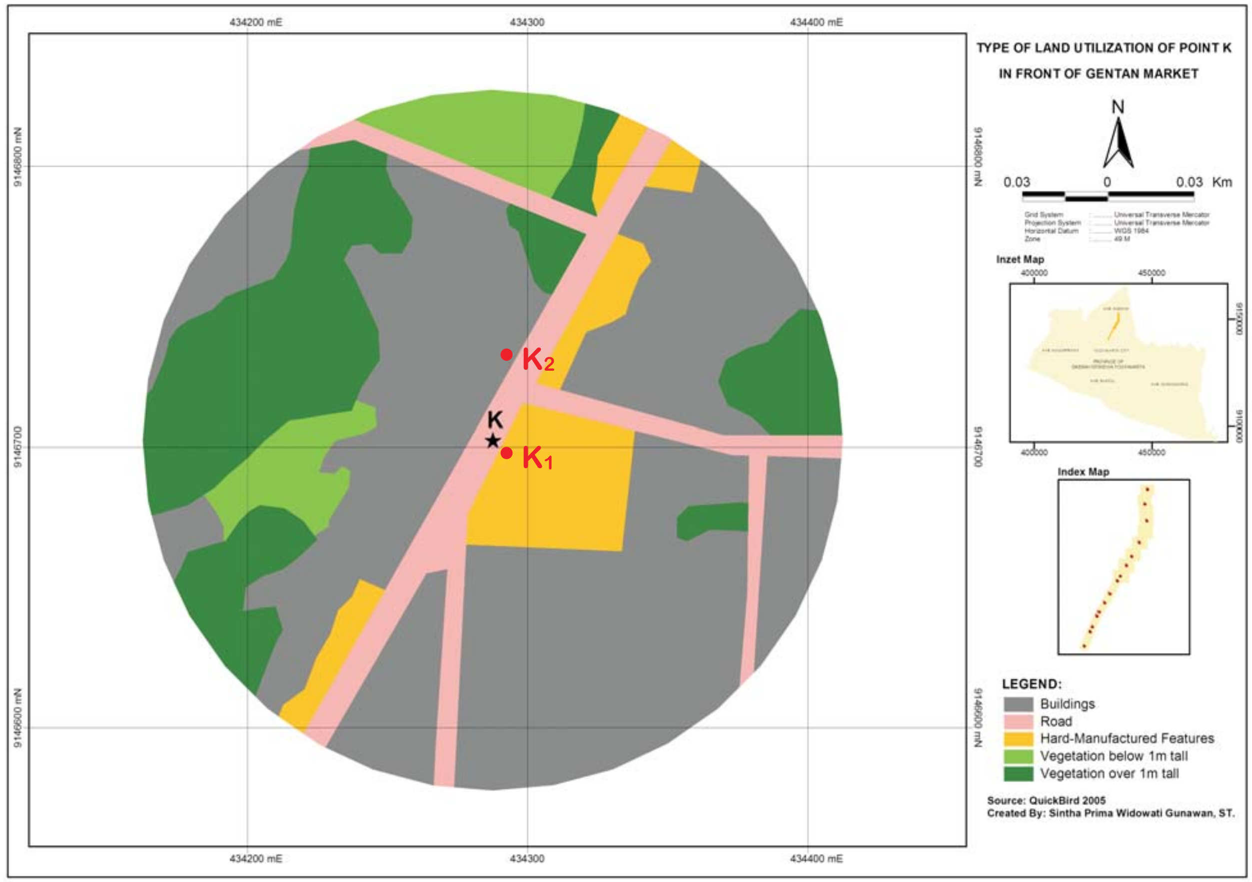


(i) Land Use Map of Point J

Appendix 12 - Point K: In front of Gentan Market

(ii) point K1

(iii) point K2



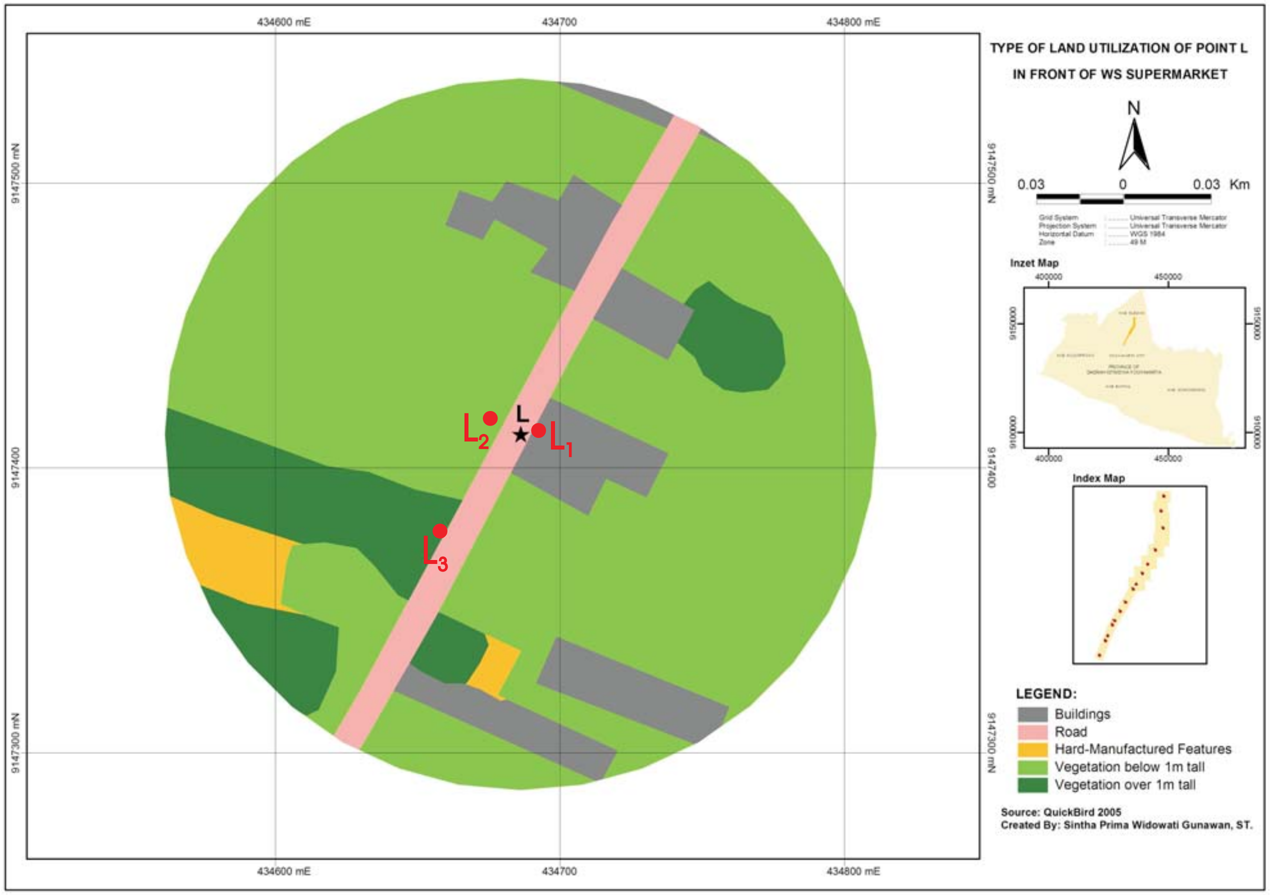
(i) Land Use Map of Point K

Appendix 13 - Point L: In front of WS Minimarket

(ii) point L1

(iii) point L2

(iv) point L3

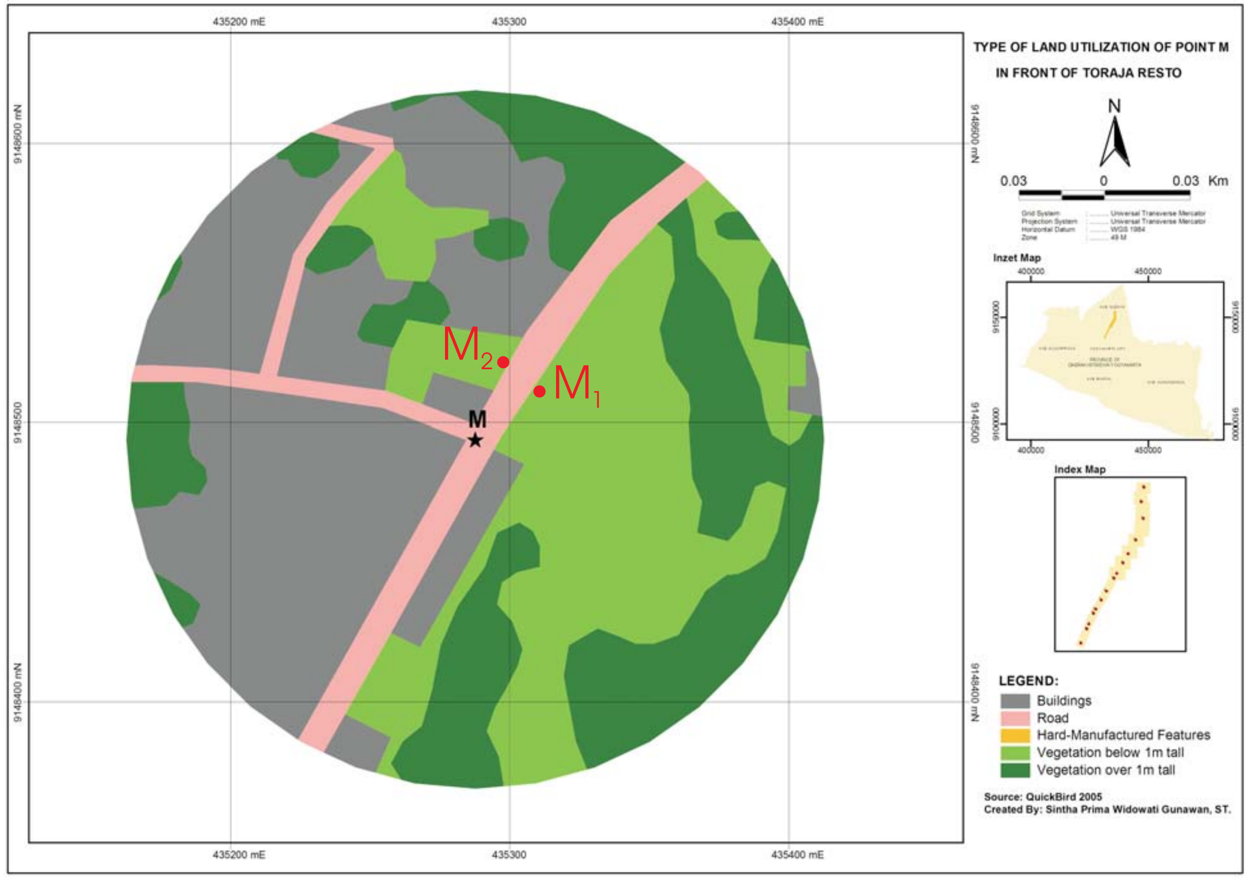


(i) Land Use Map of Point L

Appendix 14 - Point M: In front of Toraja Sea Food Restaurant

(ii) point M1

(iii) point M2



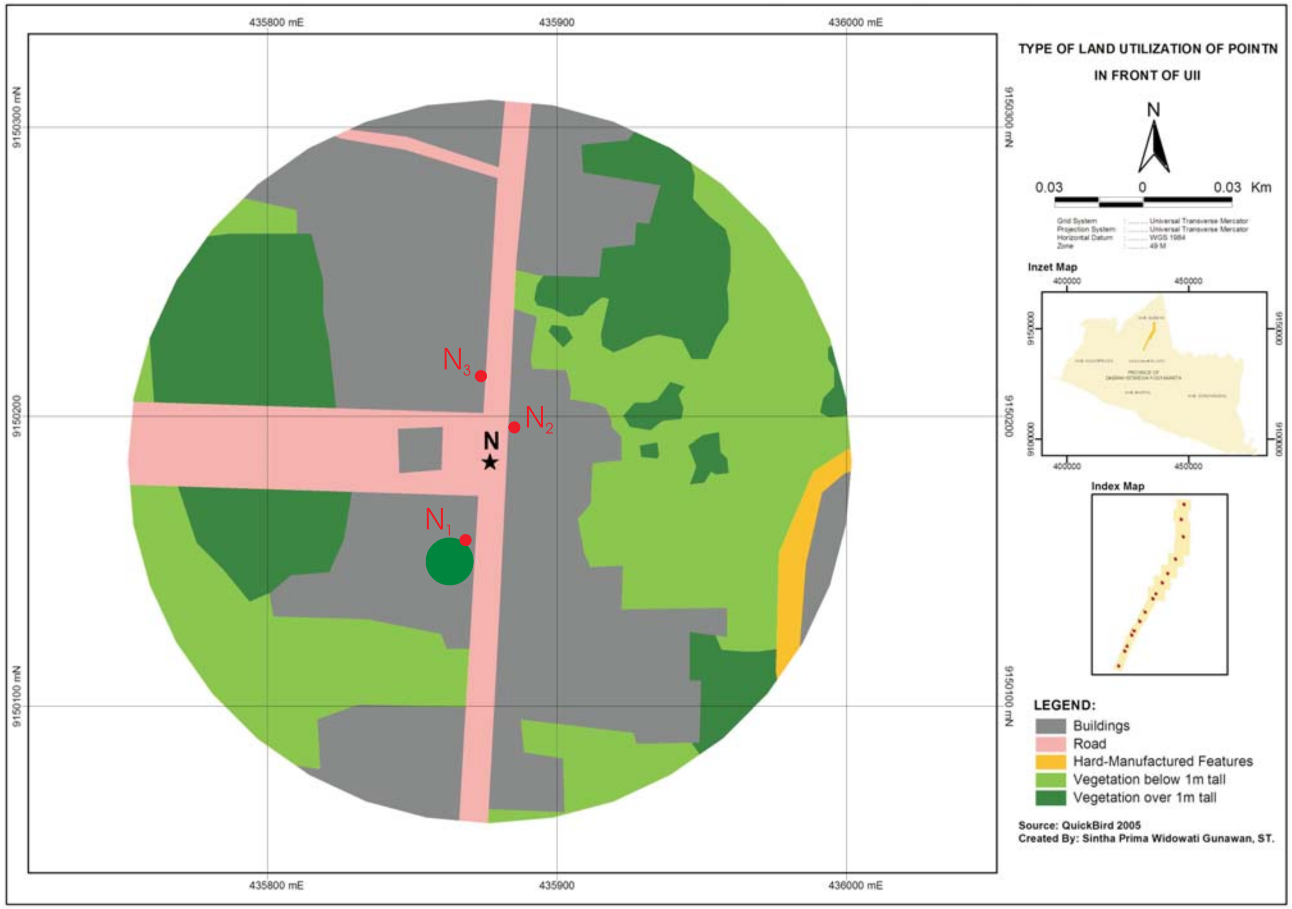
(i) Land Use Map of Point M

Appendix 15 - Point N: In front of UII Campus


(ii) point N1

(iii) point N2


(iv) point N3



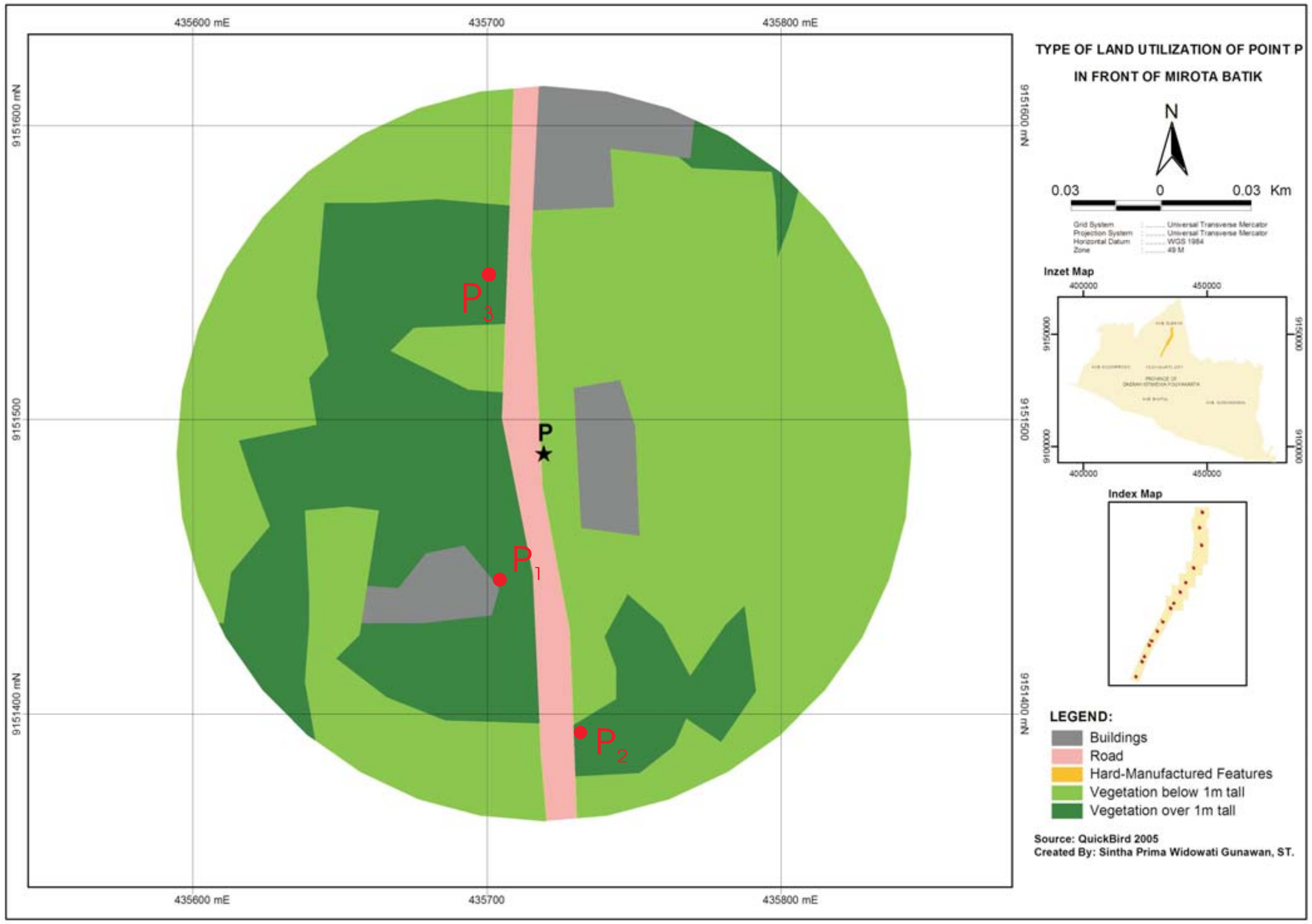
(i) Land Use Map of Point N

Appendix 16 - Point P: In front of Mirota Batik

(ii) point P1

(iii) point P2

(iv) point P3



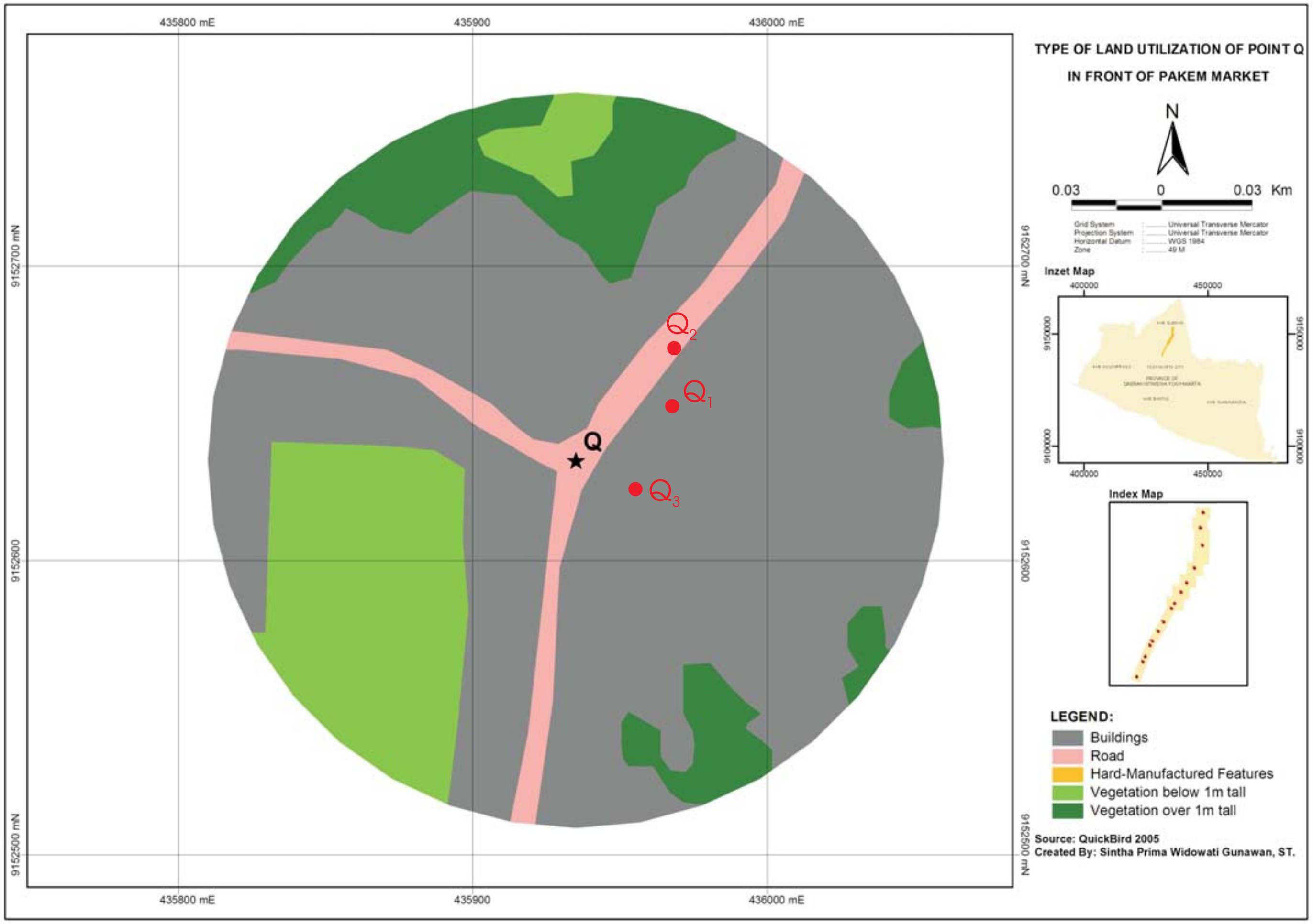
(i) Land Use Map of Point P

Appendix 17 - Point Q: In front of Pakem Market

(ii) point Q1

(iii) point Q2

(iv) point Q3



(i) Land Use Map of Point Q

Appendix 18 – Questionnaire of Driving Forces of Land Use Changes

QUESTIONNAIRE OF DRIVING FORCE OF LAND USE CHANGES IN KALIURANG STREET CORRIDOR KM 3 – KM 17

In your opinion, what are the driving factors of land use changes along Kaliurang Street Corridor from km 3 to km 17?
A list of potential driving factors of land use changes along Kaliurang Street Corridor from km 3 to km 17 is provided below. Please rank the 5 (five) leading factors with numbers from 1 (one) to 5 (five). Number 1 (one) is assigned for the highest rank and 5 (five) is assigned for the lowest rank. Any additional information can be written in the available space below the table.

No	DRIVING FORCE	RANK
1	The enhancement of transportation service to Kaliurang direction	
2	The presence of UII campus in Kaliurang Street km 14	
3	The availability of cheaper land toward north direction	
4	The presence of Kaliurang Recreation Nature Park	
5	The availability of fresh and cleaner water supply	
6	The trend of development growth in Yogya City is toward the northern fringe.	
7	The availability of natural fresh atmosphere	
8	The safe and comfort surroundings in Kaliurang Street Corridor	
9	The availability of land for future investment	
10	The availability of more spacious land	
11	The remarkable level of accessibility to the UGM campus	
12	The availability of various urban facilities along the road	
13	The cheaper price of foodstuff and daily needs	
14	The availability and quality of location to establish small-medium business	
15	The proliferating of new economic growth centers along Kaliurang Street Corridor.	

Note:

-- **Thank You** ---

Attribute Information
Institution:
Position :

Appendix 19 – Result of Traffic Counting and Speed Simulation of 15 Sampling Locations in Kaliurang Street Corridor in 2007

Sampling Point (*n=15*)	Road Width	V/C Ratio	Level of Service*	Travel Speed	Traffic Density
	m	--	--	m/s	veh./m^2
Point A: 4-junction of Mirota Kampus Supermark	10.0	0.88	E	0.85	2.57
Point B: 4-junction of MM UGM	10.0	0.87	E	0.52	3.78
Point C: In front of Gading Mas Minimarket	10.0	0.76	D	1.31	1.69
Point D: 4-junction of Kentungan	9.0	0.89	E	1.03	2.71
Point E: In front of Tina Farma Drugstore	7.0	0.80	D	1.34	0.83
Point F: In front of Colombo Market	8.0	0.86	E	0.76	0.82
Point G: In front of PLN (Regional Power Plant)	7.0	0.31	B	2.83	0.94
Point H: In front of Social Agency Book Store	7.0	0.30	B	3.43	0.85
Point J: T-junction of Merapi View	7.0	0.55	C	2.00	1.48
Point K: In front of Gentan Market	7.0	0.75	D	1.45	0.90
Point L: In front of WS Minimarket	7.0	0.28	B	3.01	0.70
Point M: In front of Toraja Sea Food Restaurant	7.0	0.26	B	3.25	0.32
Point N: In front of UII Campus	7.0	0.72	C	1.72	0.82
Point P: In front of Mirota Batik	7.0	0.28	B	5.95	0.34
Point Q: T-junction of Pakem Market	7.0	0.82	E	1.27	2.48
				2.05(Avg)	1.415(Avg)

Note: *Level of Service is referred to the Highway Capacity Manual in Table 2.7

Appendix 21 - Result of Traffic Counting and V/C Ratio Analysis of Intersection with Signal in Point A

(i) Traffic Volume at Point A - Mirota Kampus Supermarket Intersection

Day /Date : **Tuesday, 15 January 2008** **Time :** **06.30 - 8.00 WIB**

Segment Code	Direction	Light Vehicle (LV) emp protected current (P) = 1.0 emp opposed current (O) = 1.0			Heavy Vehicle (HV) emp protected current (P) = 1.3 emp opposed current (O) = 1.3			Motor Cycle (MC) emp protected current (P) = 0.2 emp opposed current (O) = 0.4			Motorized Vehicle (MV) Total MV			Turning Ratio		Un-motorized UM Current	(
		veh/ hour	smp/hour P	smp/hour O	veh/ hour	smp/hour P	smp/hour O	veh/ hour	smp/hour P	smp/hour O	veh/ hour	smp/hour P	smp/hour O	P LT	P RT	veh/ hour	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
North	LT/LTOR	86	86	86	-	-	-	144	29	58	230	115	144	0.26		15	
	ST	105	105	105	-	-	-	504	101	202	609	206	307			16	
	RT	75	75	75	-	-	-	247	49	99	322	124	174		0.28	11	
	Total	266	266	266	-	-	-	895	179	358	1,161	445	624			42	
East	LT/LTOR	194	194	194	1	1	1	711	142	284	906	338	480	0.18		33	
	ST	108	108	108	-	-	-	147	29	59	255	137	167			4	
	RT	564	564	564	541	703	703	477	95	191	1,582	1,363	1,458		0.69	10	
	Total	866	866	866	542	705	705	1,335	267	534	2,743	1,838	2,105			47	
South	LT/LTOR	34	34	34	-	-	-	125	25	50	159	59	84	0.03		8	
	ST	178	178	178	1	1	1	848	170	339	1,027	349	519			14	
	RT	571	571	571	565	735	735	490	98	196	1,626	1,404	1,502		0.71	6	
	Total	783	783	783	566	736	736	1,463	293	585	2,812	1,811	2,104			28	
West	LT/LTOR	42	42	42	-	-	-	87	17	35	129	59	77	0.06		14	
	ST	245	245	245	-	-	-	1,313	263	525	1,558	508	770			12	
	RT	172	172	172	158	205	205	89	18	36	419	395	413		0.33	26	
	Total	459	459	459	158	205	205	1,489	298	596	2,106	962	1,260			52	

(ii) The Analysis of Intersection Capacity of Point A - Mirota Kampus Supermarket Intersection

Day/Date : Tuesday, 15 January 2008 **Time : 06.30 - 8.00 WIB**

Segment Code	Hijau dalam fase no	Segment Type	Turning Vehicle Ratio				RT Current (smp/hour)		Width effective (m)	Solid Current (smp/green period)							Corrected	Traffic Current	Flow Ratio	Phase Ratio	Green phase	Capacity smp/hour	Inter Ca
							Singular Direction	Opposed Direction		Original smp/green period	Correction Factors												
											All Segment Types				P Type								
											City size	Side feature	Slope	Parking	Turn Right	Turn Left	smp/green period	smp/hour	FR	PR= Frcrit	sec	S x g/c	
			P_{LTOR}	P_{LT}	P_{RT}	Total	Q_{RT}	Q_{RTO}	W_e	So	F_{CS}	F_{SF}	F_G	F_P	F_{RT}	F_{LT}	S	Q	Q/S	IFR	g	C	(
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
North	1	P	0.26		0.28	0.54			11.5	6900	1	0.92	1.00	1.00	1.07	0.96	6,527	330	0.051	0.066	7	376	
East	2	P	0.18		0.69	0.88			6	3600	1	0.92	1.00	1.00	1.18	0.97	3,794	1,500	0.395	0.517	56	1,707	
South	3	P	0.03		0.71	0.75			14	8400	1	0.92	1.00	1.00	1.19	0.99	9,114	1,752	0.192	0.251	27	1,994	
West	4	P	0.06		0.33	0.39			12	7200	1	0.92	1.00	1.00	1.09	0.99	7,118	903	0.127	0.166	18	1,027	

Total Loss Period L LTI (second) = 16

Cycle period prior to correction c us (sec) 123.47

Cycle period after correction c (sec) 123

IFR = ∑FR crit 0.765

Appendix 22 – Result of Ambient Lead Level Monitoring of 15 Sampling Locations in Kaliurang Street Corridor in 2007

Sampling Point (*n=15*)	Ambient Pb Level (1hr-concentration)
	µg/m^3
Point A: 4-junction of Mirota Kampus Supermarket	1.773
Point B: 4-junction of MM UGM	1.548
Point C: In front of Gading Mas Minimarket	1.058
Point D: 4-junction of Kentungan	1.545
Point E: In front of Tina Farma Drugstore	1.021
Point F: In front of Colombo Market	2.000
Point G: In front of PLN (Regional Power Plant)	0.086
Point H: In front of Social Agency Book Store	0.086
Point J: T-junction of Merapi View	0.550
Point K: In front of Gentan Market	1.057
Point L: In front of WS Minimarket	0.046
Point M: In front of Toraja Sea Food Restaurant	0.040
Point N: In front of UII Campus	1.110
Point P: In front of Mirota Batik	0.014
Point Q: In front of Pakem Market	1.539

Appendix 23 – Result of Multiple Linear Regressions (OLS Method) of the Correlation of Land Use Changes and Transportation Factors to the Ambient Lead Level

(i) Model Summary(b)

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
.988(a)	.976	.963	.320553	1.874

a Predictors: (Constant), Ln_RoadVegt, Ln_TraffDens, Ln_BuildDens, Ln_VCratio, Ln_TravSpeed
b Dependent Variable: Ambient Pb Level

(ii) ANOVA(b)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	37.807	5	7.561	73.586	.000(a)
Residual	.925	9	.103		
Total	38.731	14			

a Predictors: (Constant), Ln_RoadVegt, Ln_TraffDens, Ln_BuildDens, Ln_VCratio, Ln_TravSpeed
b Dependent Variable: Ambient Pb Level

(iii) Coefficients(a)

	Unstandardized Coefficients		Regression Coefficients	t-value	P-value	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-.166	1.627		-.102	.921					
Ln_BuildDens	.341	.203	.137	1.677	.128	.767	.488	.086	.398	2.513
Ln_TraffDens	.173	.192	.076	.905	.389	.687	.289	.047	.376	2.660
Ln_TravSpeed	-.501	.294	-.199	-1.705	.122	-.857	-.494	-.088	.194	5.161
Ln_VCratio	2.199	.348	.655	6.310	.000	.965	.903	.325	.246	4.064
Ln_RoadVegt	-.050	.149	-.026	-.334	.746	-.607	-.111	-.017	.449	2.229

a Dependent Variable: Ambient Pb Level

(iv) Coefficient Correlations(a)

		Ln_RoadVegt	Ln_TraffDens	Ln_BuildDens	Ln_VCratio	Ln_TravSpeed
Correlations	Ln_RoadVegt	1.000	.156	.413	.520	.411
	Ln_TraffDens	.156	1.000	.203	.030	.636
	Ln_BuildDens	.413	.203	1.000	-.113	.391
	Ln_VCratio	.520	.030	-.113	1.000	.537
	Ln_TravSpeed	.411	.636	.391	.537	1.000
Covariances	Ln_RoadVegt	.022	.004	.012	.027	.018
	Ln_TraffDens	.004	.037	.008	.002	.036
	Ln_BuildDens	.012	.008	.041	-.008	.023
	Ln_VCratio	.027	.002	-.008	.121	.055
	Ln_TravSpeed	.018	.036	.023	.055	.087

a Dependent Variable: Ambient Pb Level

(v) Collinearity Diagnostics(a)

Dimension	Eigenvalue	Condition Index	Variance Proportions					
			(Constant)	Ln_BuildDens	Ln_TraffDens	Ln_TravSpeed	Ln_VCratio	Ln_RoadVegt
1	4.194	1.000	.00	.00	.00	.00	.00	.00
2	1.489	1.678	.00	.00	.15	.02	.00	.00
3	.208	4.487	.00	.01	.58	.07	.13	.00
4	.093	6.703	.00	.00	.19	.66	.39	.00
5	.013	17.632	.01	.44	.01	.00	.37	.16
6	.002	50.094	.99	.54	.06	.25	.10	.84

a Dependent Variable: Ambient Pb Level

Appendix 24 – Research Framework